

Fishery Data Series No. 91-13

Statistics for Dolly Varden on the Anchor River, Alaska, during 1990

by

L. L. Larson

June 1991

Alaska Department of Fish and Game

Division of Sport Fish



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ABSTRACT

During the period July to 15 August 1990, abundance, composition, and selected fishery statistics were estimated for Dolly Varden *Salvelinus malma* (Walbaum) on the Anchor River. A total of 10,427 fish were counted through a weir and an estimated 2,124 fish were harvested primarily in the lower 1.5 kilometers of the Anchor River. Mature Dolly Varden immigrating through the weir were generally greater than 300 millimeters fork length and mature fish harvested in the sport fishery were generally greater than 400 millimeters fork length. Tagging, relative maturity, and age-length data support the concept that Dolly Varden that immigrate into the Anchor River are primarily spawning fish of Anchor River origin. The magnitude of historic harvests and four consecutive years of declining abundance of immigrating Dolly Varden suggest that the spawning stock of Anchor River Dolly Varden are depressed from historic levels.

KEY WORDS: Anchor River, Kenai Peninsula, anadromous, Dolly Varden, creel survey, harvest, effort, weir, age composition, sex composition, maturity index, *Salvelinus malma*.

INTRODUCTION

The Anchor River on the lower Kenai Peninsula (Figure 1) supports recreational fishing for chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*, Dolly Varden *Salvelinus malma*, and anadromous (steelhead trout) and resident rainbow trout *O. mykiss*. The downstream section of this stream is crossed by the Sterling Highway making it easily accessible to the fishing public. Much of the river frontage along the lower 3 km of this stream is publicly owned, providing ample camping and parking areas. Due to the relatively small size of this stream, all fishing is conducted from the bank. The Anchor River has provided an average of 31,973 recreational fishing days (angler-days) annually from 1977 through 1989 (Mills 1979-1990). The fisheries targeting chinook salmon, coho salmon, steelhead trout, and Dolly Varden are of major importance to recreational anglers on the Anchor River, whereas the fisheries targeting resident rainbow trout and pink salmon are of lesser importance.

The recreational fishery for Dolly Varden in the Anchor River is one of the largest in Alaska and is of particular concern to resource managers. During the period 1977 to 1983, the harvest from this fishery averaged nearly 15,000 fish annually (Mills 1979-1984). In 1984, regulations for this fishery became more restrictive, bag and possession limits were reduced from 10 to five fish and the use of bait was prohibited after 16 September. Since these regulations have been in effect, the harvest of Dolly Varden has averaged approximately 3,700 fish (Table 1). Although a marked decline was observed in the harvest of Dolly Varden after initiation of the new regulations, concern has been expressed that the decline may reflect a depressed population. During 1990, the bag and possession limit for Dolly Varden was five and the use of bait was prohibited during the period 15 August through 31 December (ADFG 1990).

The Anchor River Dolly Varden stock is in decline. A weir was established on the Anchor River in 1987, providing estimates of total abundance of the Dolly Varden immigration. The number of spawners in the immigration was also estimated at the weir. There is evidence from the Statewide Harvest Survey that harvests of Dolly Varden in the late 70s and early 80s exceeded recent levels of total abundance, and abundance has continued to decline each year since the weir was established in 1987. Since 1987, the spawner exploitation rate in the sport fishery has ranged from 17% to 32% and averaged 25% (Larson 1990). Catch rates from 1987 through 1989 averaged 57% of the total abundance and were highest (70%) in 1988. Thus, in addition to removing up to one-third of the spawners each year, the sport fishery has a very large released component and it is suspected that mortality among these fish is high. The 70% catch rate and 32% spawner exploitation rate in 1988 occurred predominantly on the 300 mm to 349 mm length cohort. That same cohort, 1 year later, was depressed to less than half the expected abundance. These data, along with the continuing decline in abundance at the weir, suggest that a reduction in exploitation may be necessary to protect the Anchor River spawning stock.

This study will provide additional information necessary to manage the Dolly Varden spawning stock. The acquisition of basic Anchor River and non-Anchor

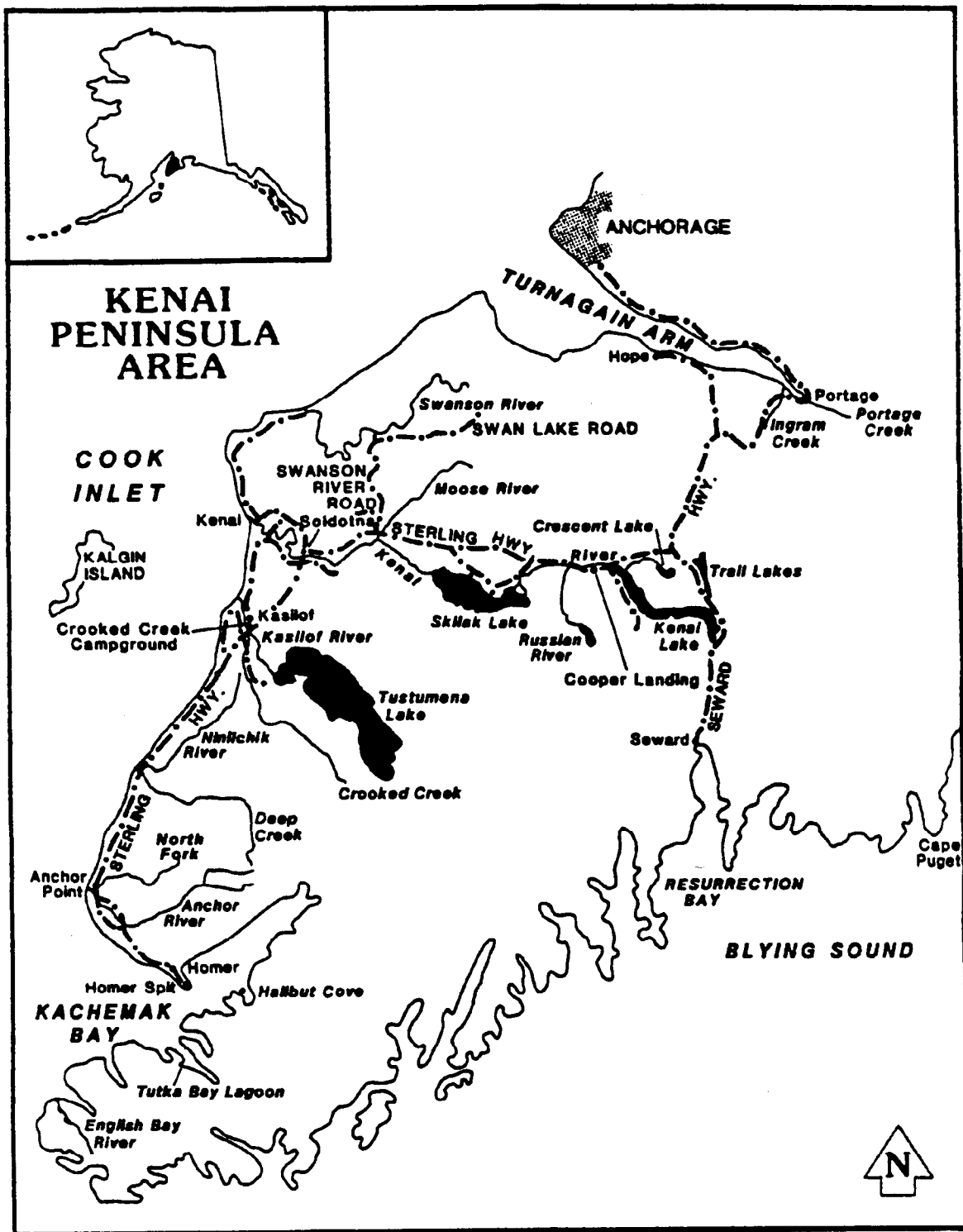


Figure 1. Map of Kenai Peninsula.

Table 1. Historical catch and harvest data from the Anchor River Dolly Varden sport fishery, 1984-1990.

Year	Creel Survey		Statewide Harvest Survey
	Catch	Harvest	Harvest
1977			9,222
1978			17,357
1979			21,364
1980			10,948
1981			15,271
1982			10,375
1983			17,277
1984			5,560
1985			7,720
1986			3,910
1987	9,414	2,653	2,735
1988	16,854	4,078	2,746
1989	5,605	1,615	1,476
1990	5,391	2,124 ^a	

^a Fishing for Dolly Varden was closed by emergency order after 7 August 1990.

River population data such as a total census, harvest, length and age composition, relative maturity, and exploitation and contribution rates to the fishery will provide the means to estimate key population parameters necessary for estimating maximum sustained yield (MSY). Since this fishery is complicated by concurrent fisheries for other species, it is also necessary to acquire specific fisheries information on all species so that additional regulatory measures (if necessary) can be effectively implemented.

Information pertaining to Dolly Varden has been presented by Allin (1954, 1957), Balland (1985, 1986), Nelson et al. (1987), Larson et al. (1988, 1989), Larson (1990), Wallis and Balland (1981-1984) and Wallis and Hammarstrom (1979-1982). Harvest and effort estimates have been reported by Mills (1979-1990).

METHODS

Study Design

This is the fifth year of what is envisioned to be a long-term study of lower Kenai Peninsula Dolly Varden populations. Dynamics of anadromous southern form Dolly Varden (Behnke 1980) populations are complex because they typically exhibit complicated migratory and homing patterns involving lake and non-lake watersheds (Armstrong 1965 and 1984; Sonnichsen 1990). Dolly Varden typically overwinter in lakes, but may spawn in either a lake system or a non-lake system. The Anchor River, which is the major study stream, is a non-lake system.

Sport Fishery

A roving creel survey (Neuhold and Lu 1957) was conducted on the Anchor River from 2 July to 2 September 1990. The creel survey provided estimates of harvest and effort by recreational anglers. The creel survey used a stratified sample design. The season was separated into two strata, the first from 2 July to 7 August and the second from 8 August to 2 September. In addition, a two-stage sample design was used, with days representing the first stage and angler counts and angler interviews representing the second stage. Within the day, effort was estimated using angler counts and HPUE (harvest per unit effort) and CPUE (catch per unit of effort) were estimated from angler interviews. Past observations indicated that angler effort between the hours of 2200 to 0600 hours was insignificant so the fishing day was defined as 16 hours in duration (0600-2200 hours) and was stratified into two daily time strata (referred to as periods): (A) 0600-1359 hours and (B) 1400-2159 hours. Thus, there were four strata for which total catch, harvest, and effort were estimated.

Sample days were selected systematically. The A period was sampled every fourth day and the B period every third day. This resulted in 16 samples taken in period A and 21 in period B during July and August combined. Once a period was chosen, the entire 8-hour period was sampled. Three counts were made systematically within each period, such that the first count time was chosen randomly from the first four 40-minute time units within the first

160-minute time block (3 X 160 minutes = one 8-hour period) and the next two counts were placed at 2 hour and 40 minute intervals. Interviews were collected over the remainder of each 160-minute time block for a total of 6 hours in each sample period. This survey design was expected to provide estimates within the level of accuracy and precision specified in the objectives.

Only anglers actively engaged in fishing during the count hour were counted. Angler counts were recorded separately for the area downstream and upstream of the weir during weir operations. The interview recorded hours fished and fish caught and released separately for the two areas. Only completed interviews were used to estimate mean CPUE and HPUE. Completed-trip anglers were surveyed for demographic information, terminal gear selection, target species, and fishing location.

The creel technician collected a random sample of harvested Dolly Varden for sex, age, relative maturity (females only), and fork length.

The following equations were used to obtain catch and harvest estimates, along with their variances for each stratum. The catch and harvest were estimated for each sample period within a stratum, and estimated sample period mean catch (or harvest) was expanded over all sample periods in the stratum. The sample period catch (or harvest) was estimated by expanding estimated CPUE (or HPUE) by estimated effort (in angler-hours).

The first step in estimating the catch or harvest of Dolly Varden involved estimating the CPUE or HPUE for expansion purposes. In order to minimize bias in estimation of CPUE and HPUE a jackknife method was used (Efron 1982).

$$\begin{aligned}
 \text{CPUE}_{hij}^* &= \text{the } j\text{th jackknifed estimate of CPUE;} \\
 &= \frac{\sum_{k=1}^{m_{hi}} c_{hik}}{\sum_{k=1}^{m_{hi}} e_{hik}} \quad [1]
 \end{aligned}$$

where:

- h = subscript denoting stratum;
- i = subscript denoting day sampled;
- j & k = subscripts denoting the angler interviewed;
- m_{hi} = number of anglers interviewed during day i within stratum h;

c_{hik} = number of Dolly Varden caught by the k th angler interviewed during day i within stratum h ; and

e_{hik} = number of hours fished by the k th angler interviewed during day i within stratum h .

Next, the mean jackknifed CPUE over all anglers interviewed in each sample was obtained:

$$\overline{CPUE}_{hi}^* = \frac{1}{m_{hi}} \sum_{j=1}^{m_{hi}} CPUE_{hij}^* \quad [2]$$

A bias correction was performed (Efron 1982):

$$\overline{CPUE}_{hi}^{*\dagger} = m_{hi}(\overline{CPUE}_{hi} - \overline{CPUE}_{hi}^*) + \overline{CPUE}_{hi}^* \quad [3]$$

where:

$$\begin{aligned} \overline{CPUE}_{hi} &= \text{the "standard" mean CPUE (without jackknifing);} \\ &= \frac{\sum_{j=1}^{m_{hi}} c_{hij}}{\sum_{j=1}^{m_{hi}} e_{hij}} \end{aligned} \quad [4]$$

Next, the bias-corrected mean jackknifed CPUE's were expanded by the estimated sample effort to obtain the estimated catch in each sample:

$$\hat{C}_{hi} = \hat{E}_{hi} \overline{CPUE}_{hi}^{*\dagger} \quad [5]$$

where:

$$\begin{aligned} \hat{E}_{hi} &= \text{estimated angler effort expended by all anglers fishing during the } i\text{th sampled period, obtained as follows:} \\ &= H_{hi} \bar{x}_{hi} \end{aligned} \quad [6]$$

where:

$$\begin{aligned} H_{hi} &= \text{number of hours during each day within sample unit } i; \\ \bar{x}_{hi} &= \text{mean angler count during the } i\text{th sample within stratum } h; \end{aligned}$$

$$= \frac{1}{r_{hi}} \sum_{o=1}^{r_{hi}} x_{hio} \quad [7]$$

where:

- o = subscript denoting the count conducted within sample i and stratum h ;
- r_{hi} = number of angler counts conducted within sample i and stratum h ; and
- x_{hio} = the number of anglers counted (fishing) during count o within sample i and stratum h .

Then the mean estimated catch was obtained over all samples within stratum h :

$$\frac{\hat{C}}{d_h} = \frac{1}{d_h} \sum_{i=1}^{d_h} C_{hi} \quad [8]$$

where:

- d_h = the number of days sampled (day = sampling unit) in stratum h .

The overall stratum catch estimate was then obtained by expanding for the number of days in each stratum:

$$\hat{C}_h = D_h \frac{\hat{C}}{d_h} \quad [9]$$

where:

- D_h = total number of days or sampling units in stratum h .

Finally, the total catch over all strata (or select combinations of strata) was obtained by summing the appropriate catch estimates:

$$\hat{C} = \sum_{h=1}^L \hat{C}_h \quad [10]$$

where:

- L = total number of strata in the fishery survey.

The estimated variance of catch for this stratified two-stage sampling design was obtained as follows (Cochran 1977):

$$\hat{V}[\hat{C}_h] = [(1 - f_{1h}) \frac{D_h^2 S_{1h}^2}{d_h}] + [D_h \sum_{i=1}^{d_h} \frac{\hat{V}[C_{hi}]}{d_h}] \quad [11]$$

where:

$$\begin{aligned} f_{1h} &= \text{sampling fraction for days;} \\ &= d_h / D_h . \end{aligned} \quad [12]$$

The variance equation for a systematic sample (Wolter 1985) was used to estimate the variance among days when the systematic sample design was successfully carried out;

$$s_{1h}^2 = \frac{\sum_{i=2}^{d_h} (\hat{C}_{hi} - \hat{C}_{h(i-1)})^2}{2(d_h - 1)} . \quad [13]$$

In some strata one or more sample days were not successfully sampled and the variance among days was estimated as follows:

$$s_{1h}^2 = \frac{\sum_{i=1}^{d_h} (\hat{C}_{hi} - \bar{\hat{C}}_h)^2}{(d_h - 1)} . \quad [14]$$

The estimated variance of the sample estimate of catch is obtained by the formula for the variance of a product of random variables as proposed by Goodman (1960):

$$\hat{V}[\hat{C}_{hi}] = \hat{E}_{hi}^2 s_{2hi}^2 + (\overline{CPUE}_{hi})^2 \hat{V}[\hat{E}_{hi}] - s_{2hi}^2 \hat{V}[\hat{E}_{hi}] \quad [15]$$

where s_{2hi}^2 is the jackknife estimate of the variance of the estimated sample CPUE as described by Efron (1982) and:

$$s_{2hi}^2 = \frac{(m_{hi} - 1)}{m_{hi}} \sum_{j=1}^{m_{hi}} (CPUE_{hij}^* - \overline{CPUE}_{hi}^*)^2 \quad [16]$$

the estimated variance of estimated sample angler effort is (Wolter 1985):

$$\hat{V}[\hat{E}_{hi}] = \frac{H_h^2}{r_{hi}} \frac{\sum_{o=2}^{r_{hi}} (x_{hio} - x_{hi(o-1)})^2}{2(r_{hi} - 1)} . \quad [17]$$

The overall variance for all strata (or select combinations of strata) was obtained by summing the variances for each strata:

$$\hat{V}[\hat{C}] = \sum_{h=1}^L \hat{V}[\hat{C}_h] . \quad [18]$$

Harvest estimates were obtained similarly by replacing the appropriate harvest statistics in place of the catch statistics in the above equations.

Effort and its variance were estimated by substituting the estimated mean sample effort (E_{hi}) in equations 9 to 13.

The assumptions of this estimator are:

1. CPUE and HPUE of interviewed anglers is representative of the CPUE and HPUE of all anglers during the sample period.
2. There is no significant fishing effort or catch taking place during times outside of the defined fishing day.

Anchor River Weir

A weir was installed approximately 1.5 km upstream from the saltwater terminus of the Anchor River (Figure 2). The weir structure was constructed of both rigid and floating weir panels. The rigid panel pickets were 1.25 cm diameter solid aluminum rods placed in an aluminum channel framework having a 1.25 cm gap between pickets. Channel frames were 3.6 m long by 1.05 m high. The aluminum frames rested against wooden tripods spaced approximately 3.0 m apart. The floating panel pickets were 2.5 cm diameter hollow PVC tubing, capped at each end to provide buoyancy, having a 1.5 cm gap between pickets. Each panel, 4.5 m long, was anchored at one end to a cable and railroad track hinge system laid perpendicular to the stream flow and along the stream bottom. A resistance board fastened to the downstream end of each panel provided the necessary lift to the panels as river water depth varied. Traps were installed to capture both upstream and downstream migrating fish.

All fish passing through the upstream and downstream traps were counted by species and examined for tags and evidence of angler hook wounds. All tagged Dolly Varden were measured to the nearest millimeter from tip-of-snout to fork-of-tail (fork length). Dolly Varden were anesthetized in a CO₂ water bath prior to being measured.

Biological Sampling

Approximately 4% of the Dolly Varden immigration were sampled for age (otolith removal), sex, relative maturity (female gonad development), and weight. Approximately 8% were sampled for length. Relative maturity of each female was determined by using the criteria described by Blackett (1968).

Weir samples were chosen by randomly selecting a trap load and sampling all fish from that trap load. Mortalities at the weir and samples from the sport harvest were sampled for age, sex, relative maturity, and length. Mortalities were also examined for injuries. Age was estimated from otoliths. Sex determination was based on examination of gonads. Fork length was measured to the nearest millimeter.

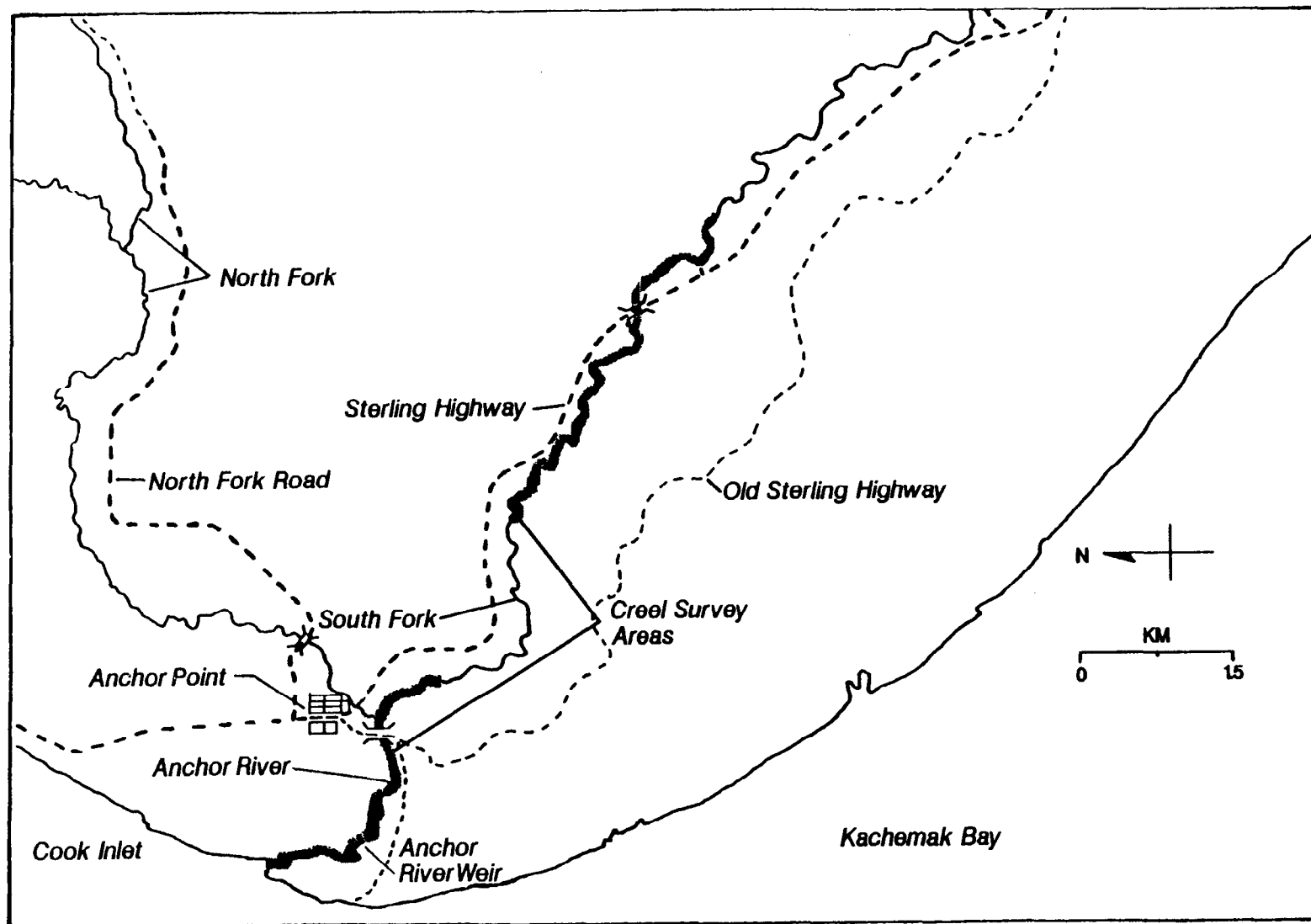


Figure 2. Map of the Anchor River.

These data were used to estimate age composition, sex composition, length frequency, and length-at-age. Age and sex composition were estimated as simple proportions. Letting P_h equal the estimated proportion of age or sex group h , the variance of P_h was estimated by (Scheaffer et al. 1979):

$$V(\hat{P}_h) = \hat{P}_h(1-\hat{P}_h)/(n_T-1) \quad [19]$$

where n_T is the total number of samples. Length-frequency was estimated in 50 mm increments.

RESULTS

Sport Fishery

Dolly Varden fishing on Anchor River, Deep Creek, Ninilchik River, and Stariski Creek was closed by emergency order effective 8 August 1990. This emergency order was issued to protect the Dolly Varden spawning stocks. Prior to 8 August, fish weir and creel survey data collected on the Anchor River indicated that Dolly Varden spawning stocks remained near 1989 levels while angler effort and catch had nearly doubled and harvest had nearly tripled since 1989.

A creel survey was conducted in selected areas of the lower 7.5 km of the Anchor River from 2 July to 2 September 1990. Angler effort, catch and harvest were estimated for the entire creel survey area (Table 2 and Appendices A1 and A2). Separate estimates for areas upstream and downstream of the weir site were prevented due to an insufficient quantity of creel data from anglers fishing upstream of the weir. Estimated effort during this period was 23,302 angler-hours, while Dolly Varden catch and harvest were 5,330 fish and 2,124 fish, respectively.

A total of 305 completed anglers were surveyed for demographic information from 2 July through 7 August (Table 3 and Appendix A3). An estimated 56% of the anglers were residents of Alaska and they accounted for 80% of the Dolly Varden harvest. Of the Alaskan residents, an estimated 51% lived more than 35 km from the Anchor River and accounted for 60% of the resident harvest. An estimated 11% of all anglers used bait, 87% used lures, and 2% used both bait and lures. Anglers who used bait were more successful in harvesting Dolly Varden than those using lures. While only 11% of the anglers used bait, they accounted for 31% of the total harvest. Of the completed anglers interviewed, 94% indicated they fished downstream of the weir structure and those who fished downstream of the weir accounted for 96% of the total recorded harvest.

Anchor River Weir

The Anchor River weir was in continual operation from 4 July through 15 August 1990. River water levels remained relatively low and clear throughout the duration of the weir operation. Depth readings were recorded daily at 2200 hours from 5 July through 15 August and temperature readings were recorded continually with a thermograph from 9 July through 15 August. Water

Table 2. Anchor River Dolly Varden effort, catch, and harvest estimates, 1990.

	Date	Period	Number of Days		Mean	Total	a S _{1h} ²	Variance Components		Total Variance	Relative Precision ^b
			Total	Sampled				Stage 1	Stage 2		
Effort	02 Jul-07 Aug	A	37	9	65	2,423	1,678	193,205	22,408	215,613	38
		B	37	13	175	6,466	12,004	819,985	39,710	859,695	28
	Subtotal					8,889				1,075,308	23
	08 Aug-02 Sep	A	26	8	213	5,547	10,329	604,270	37,613	641,883	28
		B	26	8	341	8,866	6,242	365,129	122,547	487,676	15
	Subtotal					14,413				1,129,559	14
	Total					23,302				2,204,867	12
Catch	02 Jul-07 Aug	A	37	8	31	1,143	1,207	161,873	31,640	193,513	75
		B	37	11	112	4,130	4,681	409,352	157,842	567,194	36
	Subtotal					5,273				760,707	32
	08 Aug-02 Sep	A	26	7	2	45	21	1,492	640	2,132	200
		B	26	8	0	12	2	115	47	162	207
	Subtotal					57				2,294	165
	Total					5,330				763,001	32
Harvest	02 Jul-07 Aug	A	37	8	16	599	463	62,105	11,284	73,389	89
		B	37	11	41	1,525	1,400	122,427	36,307	158,733	51
	Subtotal					2,124				232,122	44
	08 Aug-02 Sep	A	26	7	0	0	0	0	0	0	
		B	26	8	0	0	0	0	0	0	
	Subtotal					0				0	
	Total					2,124				232,122	44

^a Variance among days sampled (equation 13).

^b Relative precision = (square root (variance) X 1.96/Estimate) X 100.

Table 3. Summary of completed angler responses to questions on the use of terminal tackle, residency, and harvest from 2 July through 7 August 1990. Anglers were targeting Dolly Varden.

	Terminal Tackle				Residency		
	Used by Interviewed Anglers				Resident		Non Resident
	Bait Only	Lures Only	Both Bait and Lures	Total	Local ^a	Non Local ^b	Total
Responses:	33 (11%)	256 (87%)	6 (2%)	295	85 (49%)	87 (51%)	172 (56%)
Number Fish Harvested:	55 (31%)	123 (69%)		178	57 (40%)	86 (60%)	143 (80%)
							36 (20%)

^a Alaskan resident angler living less than 35 km from Anchor Point.

^b Alaskan resident angler living greater than 35 km from Anchor Point.

depth and temperature recorded at the upstream trap location (Appendix A4) varied from 30 cm to 41.3 cm and 10.1°C to 19.7°C, respectively. Daily water temperature readings varied from 0.9°C to 6.9°C within a 24 hour period.

A total of 10,427 Dolly Varden approximately 200 mm or greater in length were passed upstream of the Anchor River weir (Appendix A5). The peak of the immigration occurred in late July, with 50% of the run having passed the weir by 20 July (Figure 3). The timing of immigrating Dolly Varden during 1990 was consistent with the timing of the 1988 immigration (Figure 4).

One-way analysis of variance (Snedecor and Cochran 1967) was used to test the null hypothesis that there was no change in mean length of fish across weeks at the weir. The mean length of immigrating Dolly Varden sampled ($n = 789$) at the weir did change significantly ($F = 62.8$, $P < 0.001$) over time (Figure 5). The mean length decreased each week from the first week through the fifth week and then increased slightly during the sixth week. These results are consistent with those observed in 1989 (Larson 1990).

Although the total Dolly Varden counts through the weir during 1989 and 1990 were similar in magnitude, there was a significant difference in the cumulative length distribution between years (Kolmogorov-Smirnov statistic: $D_{\max} = 0.2866$; $n = 790$, 655; $P < 0.01$) (Figure 6). During 1990, the number of the 200-249 mm Dolly Varden increased more than three fold and the number of 300-349 mm Dolly Varden decreased by approximately one-half (Table 4).

The length frequency between immigrating spawners and nonspawners differed significantly at age group 4 ($D_{\max} = 0.83$; $n = 34$, 6; $P < 0.01$) and 5 ($D_{\max} = 1.0$; $n = 9$, 41; $P < 0.01$) spawners being larger than nonspawners (Table 5). The proportion of immigrating Dolly Varden nonspawners (female maturity index code 1) and spawners (female maturity index code 2) changed significantly ($X^2 = 60.46$, $df = 2$, $P < 0.01$) over time (Table 6). Nonspawners increased in abundance while spawners decreased biweekly through 15 August. These results are consistent with those observed in 1989.

A total of 414 Dolly Varden were found dead in the downstream trap or along the upstream side of the weir face (Table 7). A subjective examination for possible causes of death revealed 263 fish (63.5%) with apparent hook wounds, 73 (17.6%) fish with predator injuries, 42 (10.1%) fish with unknown injuries, 35 (8.5%) fish with no apparent injuries, and one fish with net injuries. Injuries which resulted in lesions to the skin generally had topical evidence of a bacterial infection resembling furunculosis (a necrotic lesion which ulcerates to release lightly infectious reddish fluid). Locations of hook injuries were most prevalent in three areas: the head area, ventrally between the pectoral fins, and around the dorsal fin. Hook injuries between the pectoral fins often resulted in injury to the liver.

A total of 431 Dolly Varden passed through the downstream trap from 4 July through 15 August (Appendix A6). The majority (77%) of these fish were less than 300 mm in fork length. A total of 178 Dolly Varden were examined for injuries, of these, 47.7% had apparent hook wounds (Table 7) and generally had topical evidence of a bacterial infection resembling furunculosis associated

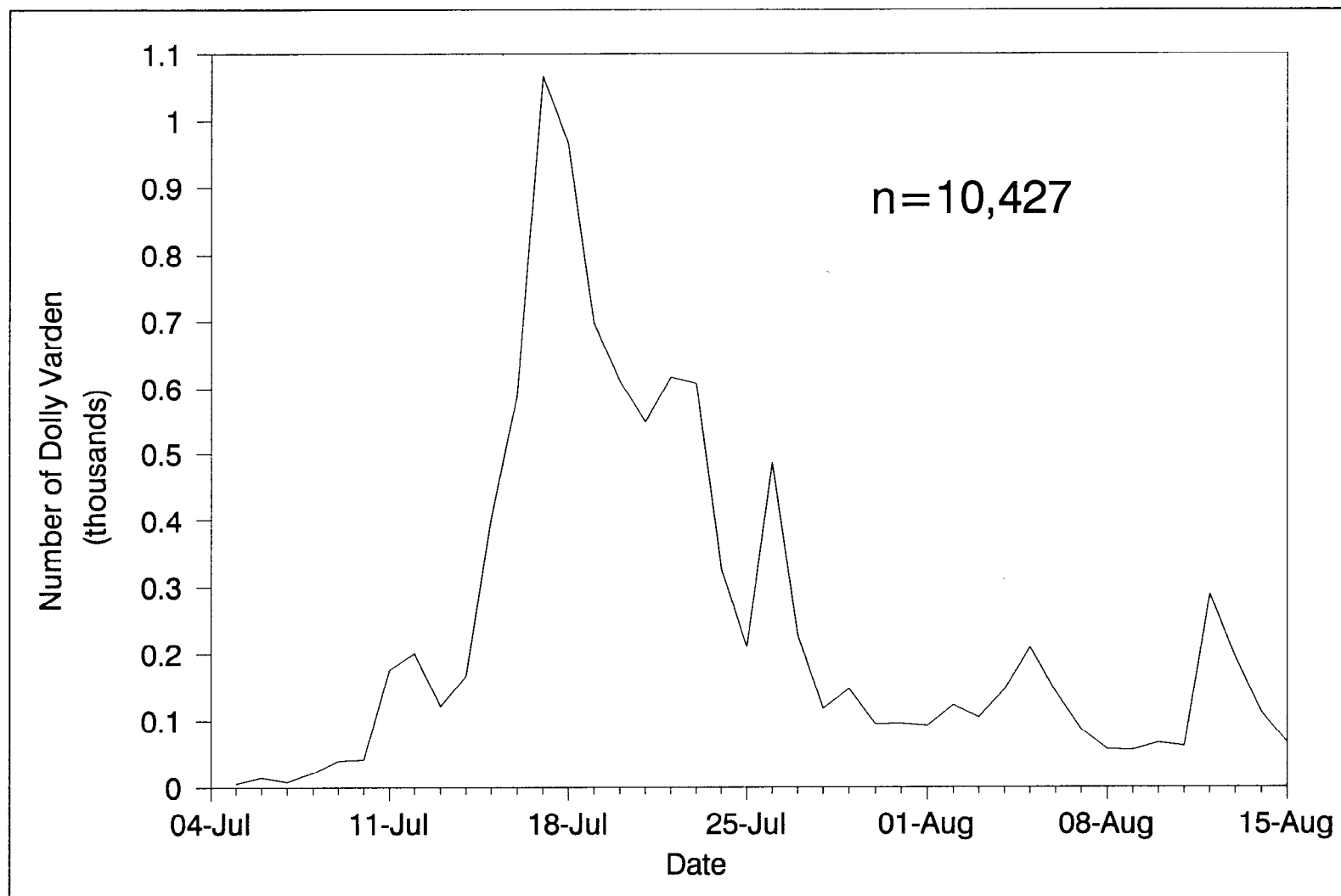


Figure 3. Counts of Dolly Varden passing upstream through the Anchor River weir, 1990.

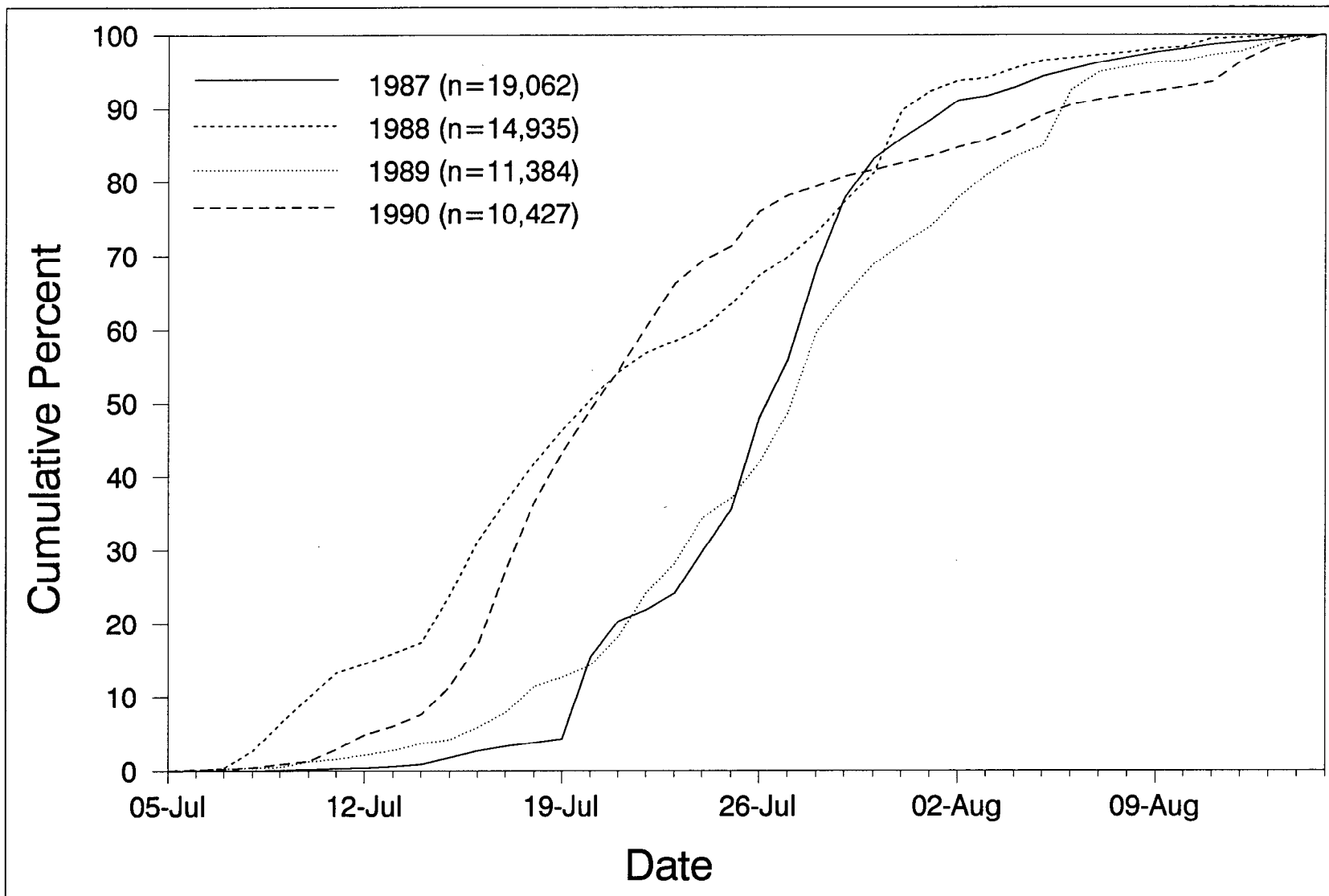


Figure 4. Anchor River Dolly Varden immigration run timing by cumulative percent from 5 July-15 August, 1987-1990.

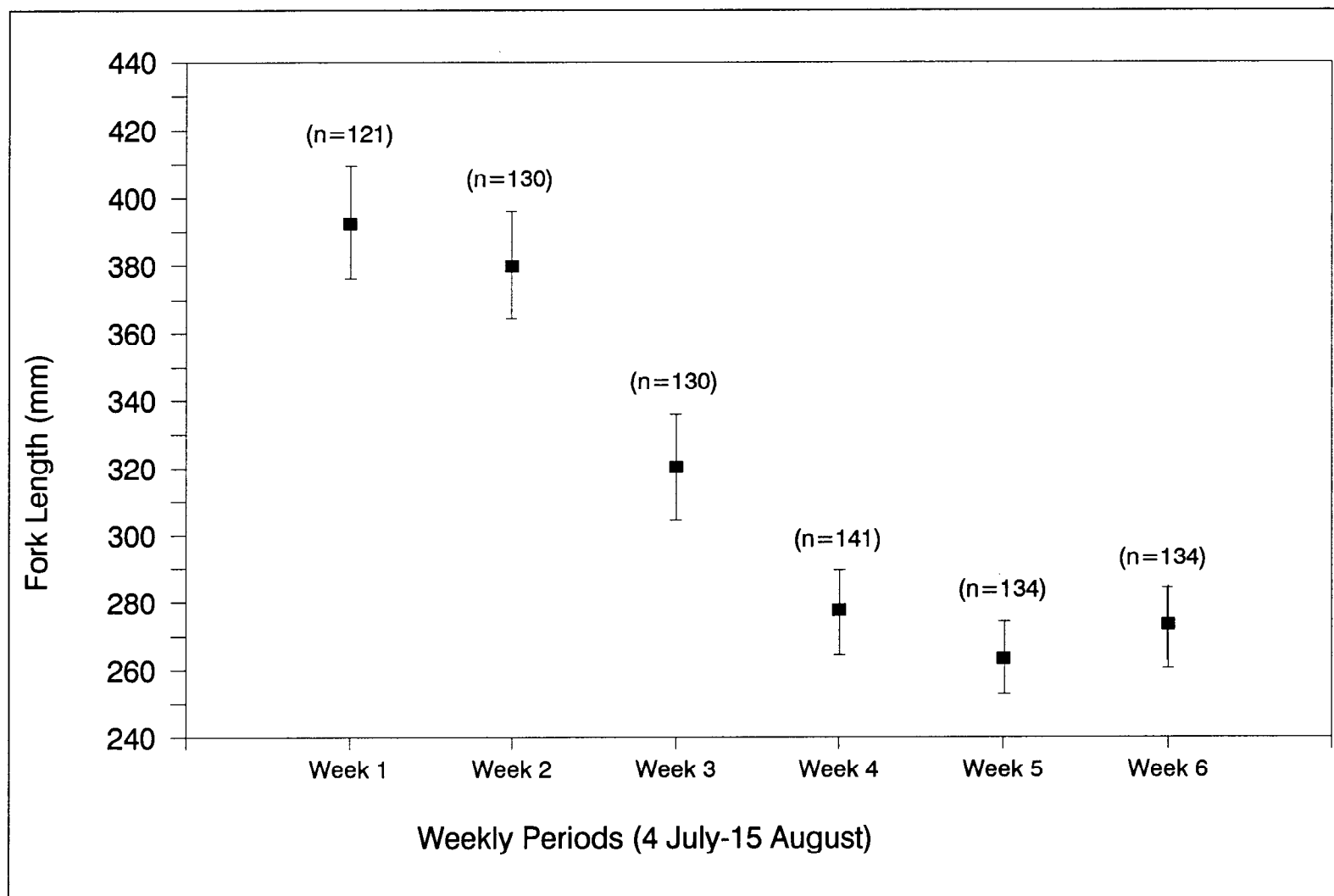


Figure 5. Mean length by period with 95% confidence intervals from Dolly Varden sampled moving upstream through the Anchor River weir, 1990.

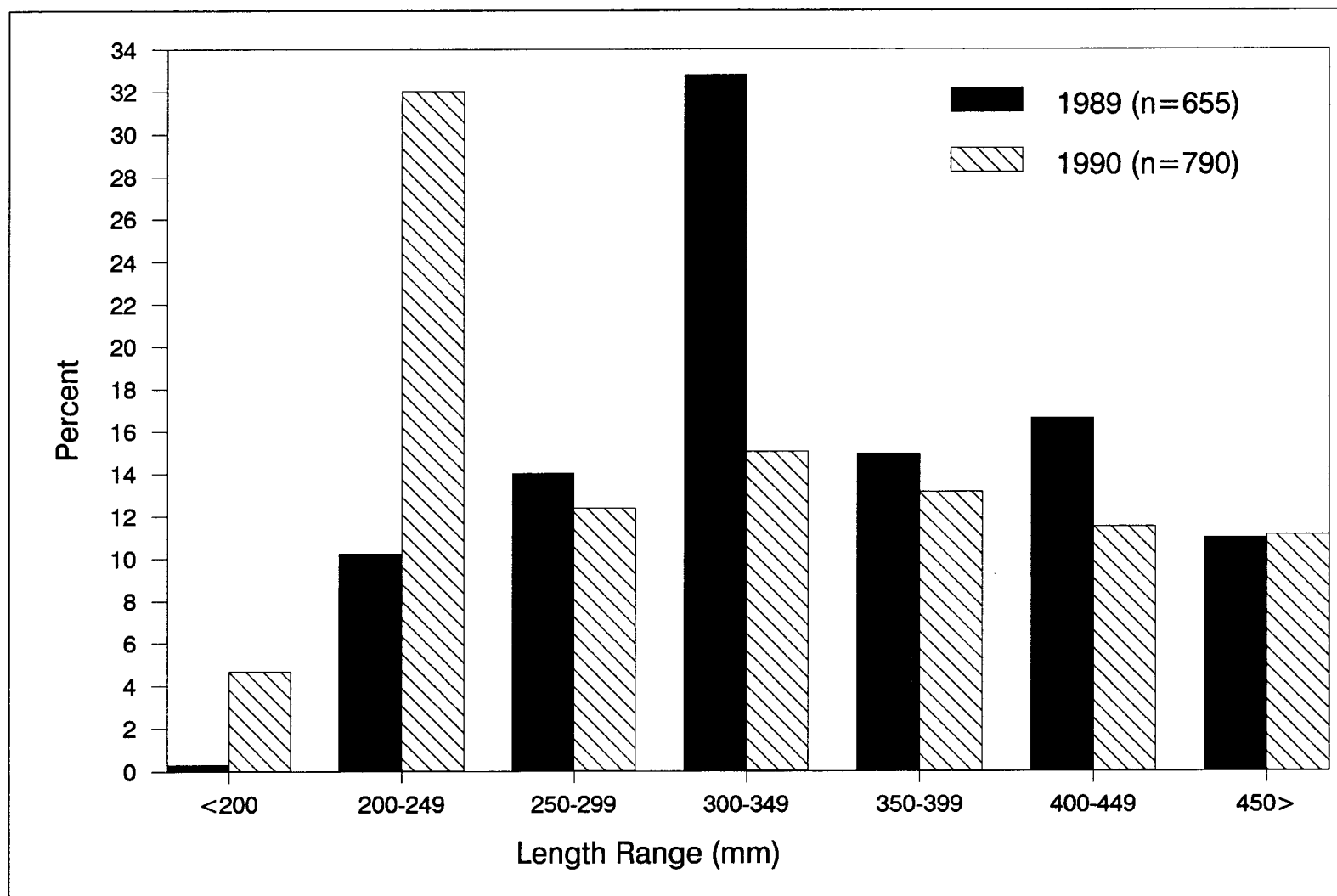


Figure 6. The percent of Dolly Varden immigrating through the Anchor River weir by length range, 1989 and 1990.

Table 4. Dolly Varden counted immigrating through the Anchor River fish weir by length range, 1987-1990.

Length Range	Year							
	1990		1989		1988		1987	
	Count	%	Count	%	Count	%	Count	%
<200	37	5	2	0	11	0	4	0
200-249	253	32	67	10	335	11	540	17
250-299	98	12	92	14	220	7	432	13
300-349	119	15	215	33	999	33	626	20
350-399	104	13	98	15	649	21	883	28
400-449	91	12	109	17	537	18	463	14
450>	88	11	72	11	271	9	259	8
Total	790	100	655	100	3,022	100	3,207	100

Table 5. Mean length (millimeters) by age group and female sexual maturity of Dolly Varden collected at the Anchor River weir site and in the sport fishery, 1990.

Component	Age Group								
	2	3	4	5	6	7	8	9	12
<u>Weir Samples (Upstream Trap)</u>									
Nonspawner (Code 1) ^a									
Mean Length	190.0	221.4	241.1	259.0	210.0	243.0			
Standard Error		5.2	5.3	16.4					
Sample Size	1	36	34	9	1	1			
Potential Spawners (Code 5)									
Mean Length			307.1	339.0	351.7	406.8		508.0	
Standard Error			12.4	10.9	32.9	21.3			
Sample Size			21	17	3	4		1	
Spawner (Codes 2, 3 & 4)									
Mean Length		235.0	334.0	424.0	419.5	451.5	503.0		535.0
Standard Error			28.0	7.7	8.0	19.2			
Sample Size		1	6	42	32	15	1		1
<u>Sport Harvest</u>									
Nonspawner (Code 1)									
Mean Length		268.5	328.2	329.7					
Standard Error		16.5	20.9	12.8					
Sample Size		2	5	3					
Potential Spawners (Code 5)									
Mean Length			396.5	370.0	418.8				
Standard Error			27.5	19.9	36.1				
Sample Size			2	3	4				
Spawner (Codes 2, 3 & 4)									
Mean Length				417.6	463.5	443.2	475.5		
Standard Error				12.5	67.5	23.5	27.5		
Sample Size				8	2	5	2		

^a Maturity Index Codes:

- 1 = immature female with egg diameter less than 0.90 mm,
- 2 = mature female with egg diameter greater than 1.75 mm,
- 3 = completely mature female (eggs easily stripped),
- 4 = completely spawned female,
- 5 = immature female but shows development, egg diameter greater than 0.90 mm and less than 1.75 mm.

Table 6. Maturity index summary of Dolly Varden sampled at the Anchor River fish weir and in the sport fishery with estimates of composition by period and maturity code for percent, mean length and total numbers of fish, 1990.

Period	Female Maturity Code ^a																Total Fish Sampled		
	1				2				3				4		5				
	Sample		Mean	Estimated	Sample		Mean	Estimated	Sample		Mean	Estimated	Sample	Sample	Mean	Estimated			
	Size	%	Length (mm)	Total Fish	Size	%	Length (mm)	Total Fish	Size	%	Length (mm)	Total Fish	Size	Size	%	Length (mm)		Total Fish	
Weir Samples																			
2-15 July	12	15.8	247	283	49	64.5	452	1,155		0.0		0		15	19.7	395	353	76	
16-31 July	16	23.9	262	1,653	39	58.2	405	4,029		0.0		0		12	17.9	327	1,240	67	
1-15 Aug	55	63.2	233	1,097	11	12.6	346	217	1	1.1	549	20		20	23.0	392	394	87	
2 July-15 Aug	83	29.1	233	3,033	99	51.8	422	5,401	1		549	20	0	47	19.1	334	1,987	230	
Sport Harvest																			
1-15 July	1	10	335	49	4	40.0	467	196						5	50.0	428	245	10	
16-31 July	4	17.4	276	230	13	56.5	433	770						6	26.1	382	351	23	
1-15 Aug	5	83.3	345	211	1	16.7	375	43						0	-		0	6	
2 July-15 Aug	10	23.4	317	490	18	48.2	437	1,009	0			0	0	11	28.5	403	596	39	

^a Maturity index codes:

- 1 = immature female with egg diameter less than 0.9 mm,
- 2 = mature female with egg diameter greater than 1.75 mm,
- 3 = completely mature female (eggs easily stripped),
- 4 = completely spawned female,
- 5 = immature female but shows development, egg diameter greater than 0.5 mm and less than 1.75 mm.

Table 7. Injuries observed by length range from Dolly Varden sampled in the emigration through the Anchor River weir and from mortalities collected at the weir site.

Length Range	<u>Dolly Varden Mortalities Collected At The Weir Site</u>										Total
	No. Injuries	%	Angler Wound	%	Net Wound	%	Unknown Injuries	%	Predator Injuries	%	
<200			7	1.7		0.0		0.0	1	0.2	8
200-249	13	3.1	87	21.0		0.0	14	3.4	27	6.5	141
250-299	4	1.0	40	9.7		0.0	8	1.9	8	1.9	60
300-349	8	1.9	73	17.6		0.0	10	2.4	18	4.3	109
350-399	5	1.2	43	10.4		0.0	6	1.4	10	2.4	64
400-449	4	1.0	11	2.7		0.0	4	1.0	7	1.7	26
450-499	1	0.2	2	0.5	1	0.2		0.0	1	0.2	5
500>		0.0		0.0		0.0		0.0	1	0.2	1
Total	35	8.5	263	63.5	1	0.2	42	10.1	73	17.6	414

Length Range	<u>Downstream Migration Of Dolly Varden Moving Through The Weir</u>										Total
	No. Injuries	%	Angler Wound	%	Net Wound	%	Unknown Injuries	%	Predator Injuries	%	
<200	7	3.9	2	1.1		0.0		0.0	2	1.1	11
200-249	44	24.7	45	25.3		0.0	1	0.6	14	7.9	104
250-299	5	2.8	18	10.1		0.0		0.0	3	1.7	26
300-349	5	2.8	15	8.4		0.0	1	0.6	3	1.7	24
350-399	3	1.7	4	2.2		0.0		0.0	1	0.6	8
400-449	1	0.6	1	0.6		0.0		0.0	2	1.1	4
450-499		0.0		0.0		0.0		0.0		0.0	0
500>	1	0.6		0.0		0.0		0.0		0.0	1
Total	66	37.0	85	47.7	0	0	2	1.1	25	14.0	178

with them. None of the injured fish released downstream with bacterial infections were observed returning through the upstream trap after release.

Biological Data

Dolly Varden sampled from the sport harvest and from the upstream weir trap were analyzed for length, age, sex, and relative maturity. All weir samples were measured for length and some were sacrificed to estimate age, sex, and relative maturity.

Dolly Varden analyzed for age from the immigration through the weir and the sport fishery ranged in age from 2 to 12 years (Table 8 and Appendix A7). The age composition between weir and sport fishery samples was significantly different ($X^2 = 12.72$, $df = 4$, $0.01 < P < 0.025$). Fish less than age 4 were more prevalent (21%) in weir samples than in the sport harvest (9%). This supports the hypothesis that anglers select fish for harvest by size.

Immigrating male Dolly Varden were predominantly age 4 and females were predominantly age 5 (Figure 7). The number of fish older than 5 dropped precipitously and the combined year-classes from 7 through 12 accounted for less than 10% of the run. These data suggest a low frequency of repeat spawning due to high natural or fishing mortality.

Of 369 fish sampled at the weir, 63% were females and of 90 fish sampled in the sport harvest, 48% were females. These ratios did not change significantly over time when compared in biweekly periods (Table 9), however, the sex ratios between the immigration through the weir and the sport harvest were significantly different ($X^2 = 7.81$, $df = 1$, $P < 0.01$).

Estimates of the Dolly Varden immigration through the weir indicate that about 52% were spawners, 19% potential spawners, and 29% nonspawners (Table 6, Figure 8, and Appendix A8). There was little difference in the total percentage of each maturity index category observed between weir samples ($n = 230$) and the sport harvest ($n = 39$) (Table 6). This was surprising because the sport harvest, which is selective towards larger fish, was expected to have proportionately fewer nonspawners than the weir samples. An estimated 88% of the sport harvest were over 300 mm in fork length (Table 10) and generally fish greater than 300 mm sampled from the immigration through the weir were spawners (Table 5 and Larson 1990).

Nonspawners harvested by the fishery averaged 40-90 mm larger than those sampled at the weir (Table 5), and the fishery removed only the largest nonspawners (Figure 9). Although the sample sizes are small, the 95% confidence intervals for mean length by age of nonspawners in the harvest do not overlap with those of non-spawners of the same age at the weir. Mean length by age of sport harvested nonspawners over the age of 3 was greater than 325 mm while mean length of all weir nonspawner samples (ages 2-7) was less than 260 mm.

Assuming that males and females have the same maturity schedule, the proportion of non-spawners and spawners in the weir count and harvest was estimated (Table 6).

Table 8. Age and sex compositions of Dolly Varden collected at the weir site and in the sport harvest on the Anchor River during 1990.

	Age Group									
Component	2	3	4	5	6	7	8	9	12	Total
<u>Weir Samples (Upstream Trap)</u>										
Male										
Percent	0.7	27.0	32.9	24.8	11.0	3.7	0.0	0.0	0.0	37.6
Sample Size	1	37	45	34	15	5	0	0	0	137
Female										
Percent	0.4	16.7	26.9	30.0	15.9	8.8	0.4	0.4	0.4	62.4
Sample Size	1	38	61	68	36	20	1	1	1	227
Sexes Combined										
Percent	0.6	20.6	29.1	28.0	14.0	6.9	0.3	0.3	0.3	100.0
Sample Size	2	75	106	102	51	25	1	1	1	364
<u>Sport Harvest</u>										
Male										
Percent	0.0	12.8	31.9	44.7	4.3	4.3	0.0	2.1	0.0	54.0
Sample Size	0	6	15	21	2	2	0	1	0	47
Female										
Percent	0.0	5.0	22.5	37.5	15.0	15.0	5.0	0.0	0.0	46.0
Sample Size	0	2	9	15	6	6	2	0	0	40
Sexes Combined										
Percent	0.0	9.2	27.6	41.4	9.2	9.2	2.3	1.2	0.0	100.0
Sample Size	0	8	24	36	8	8	2	1	0	87

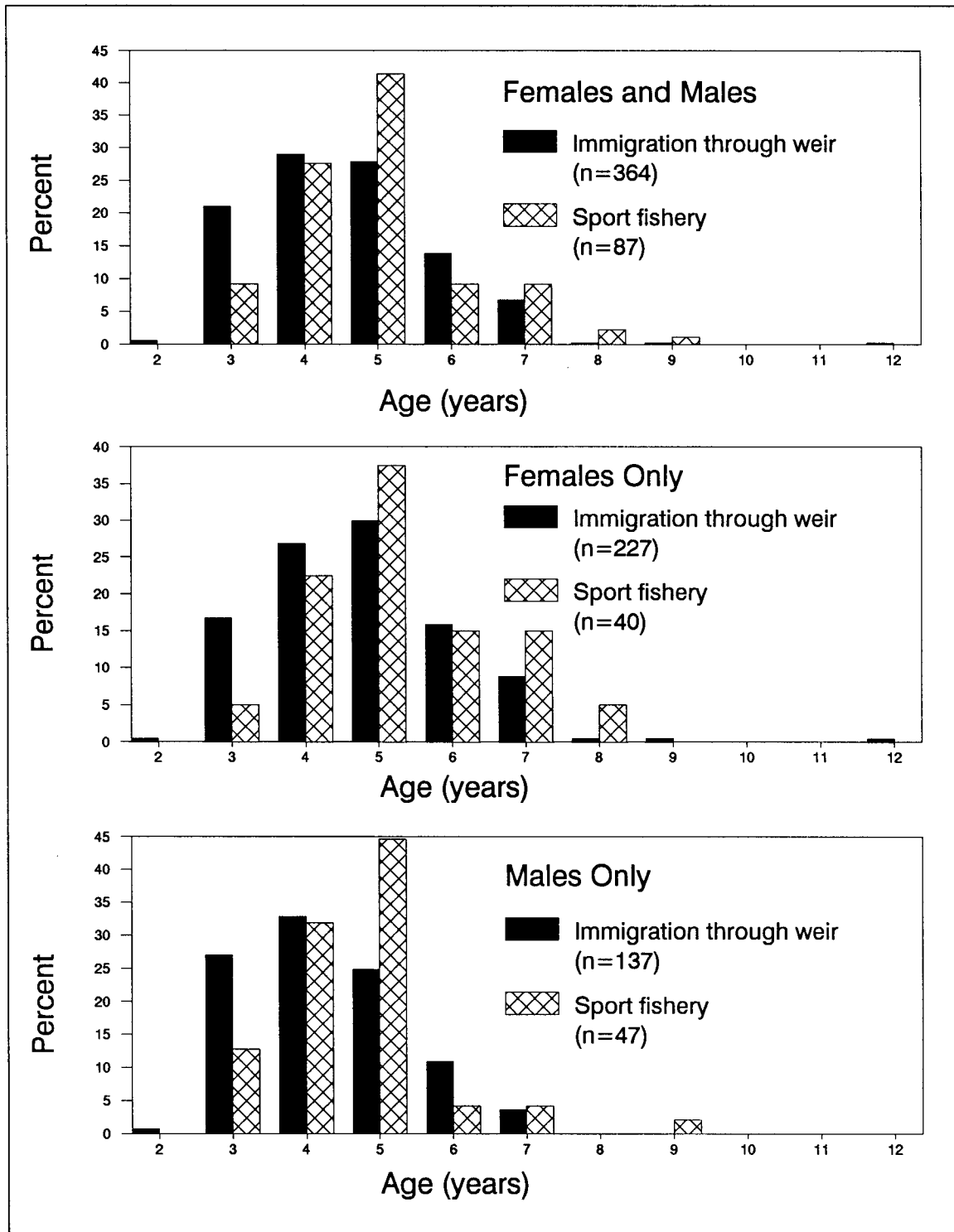


Figure 7. Age and sex composition of Dolly Varden sampled at the Anchor River weir site and in the sport fishery, 1990.

Table 9. Estimated sex ratios of Anchor River Dolly Varden sampled biweekly from the weir site and in the sport fishery, 1990.

Sex	Fish Weir						Total		Estimated Weir Population
	2 July-16 July		17 July-31 July		1 Aug-15 Aug		Count	%	
	Count	%	Count	%	Count	%			
Male	39	34	52	44	47	35	138	37	4,251
Female	77	66	67	56	87	65	231	63	6,176
Total:	116		119		134		369		10,427

Sex	Sport Fishery						Total		Estimated Harvest
	2 July-16 July		17 July-31 July		1 Aug-15 Aug		Count	%	
	Count	%	Count	%	Count	%			
Male	19	44	22	63	6	50	47	52	1,109
Female	24	56	13	37	6	50	43	48	1,015
Total:	43		35		12		90		2,124

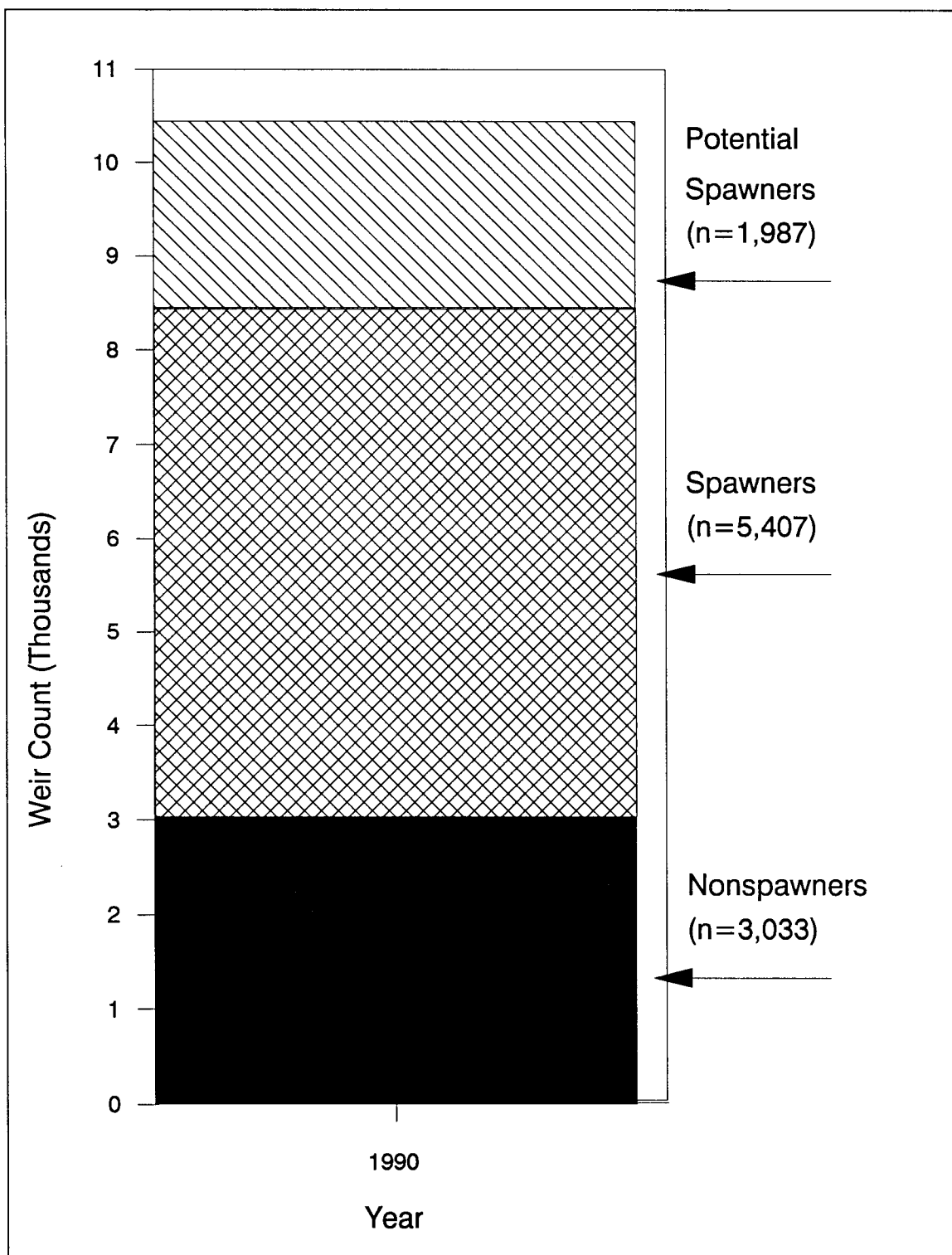


Figure 8. Sexual maturity component of immigrating Dolly Varden sampled at the Anchor River weir, 1990.

Table 10. Number of Dolly Varden sampled from the upstream trap, sport harvest, mortalities recovered at the weir site, and downstream trap, by length range, Anchor River, 1990.

Length Range	<u>Upstream Trap</u>		<u>Sport Harvest</u>		<u>Mortalities</u>		<u>Downstream Trap</u>	
	Count	%	Count	%	Count	%	Count	%
<200	37	5	0	0	8	2	11	6
200-249	253	32	3	3	141	34	104	58
250-299	98	12	8	9	60	14	26	15
300-349	119	15	25	28	109	26	24	13
350-399	104	13	25	28	64	15	8	4
400-449	91	12	15	17	26	6	4	2
450-499	64	8	8	9	5	1	0	0
500>	24	3	6	7	1	0	1	1
Total	790	100	90	100	414	100	178	100

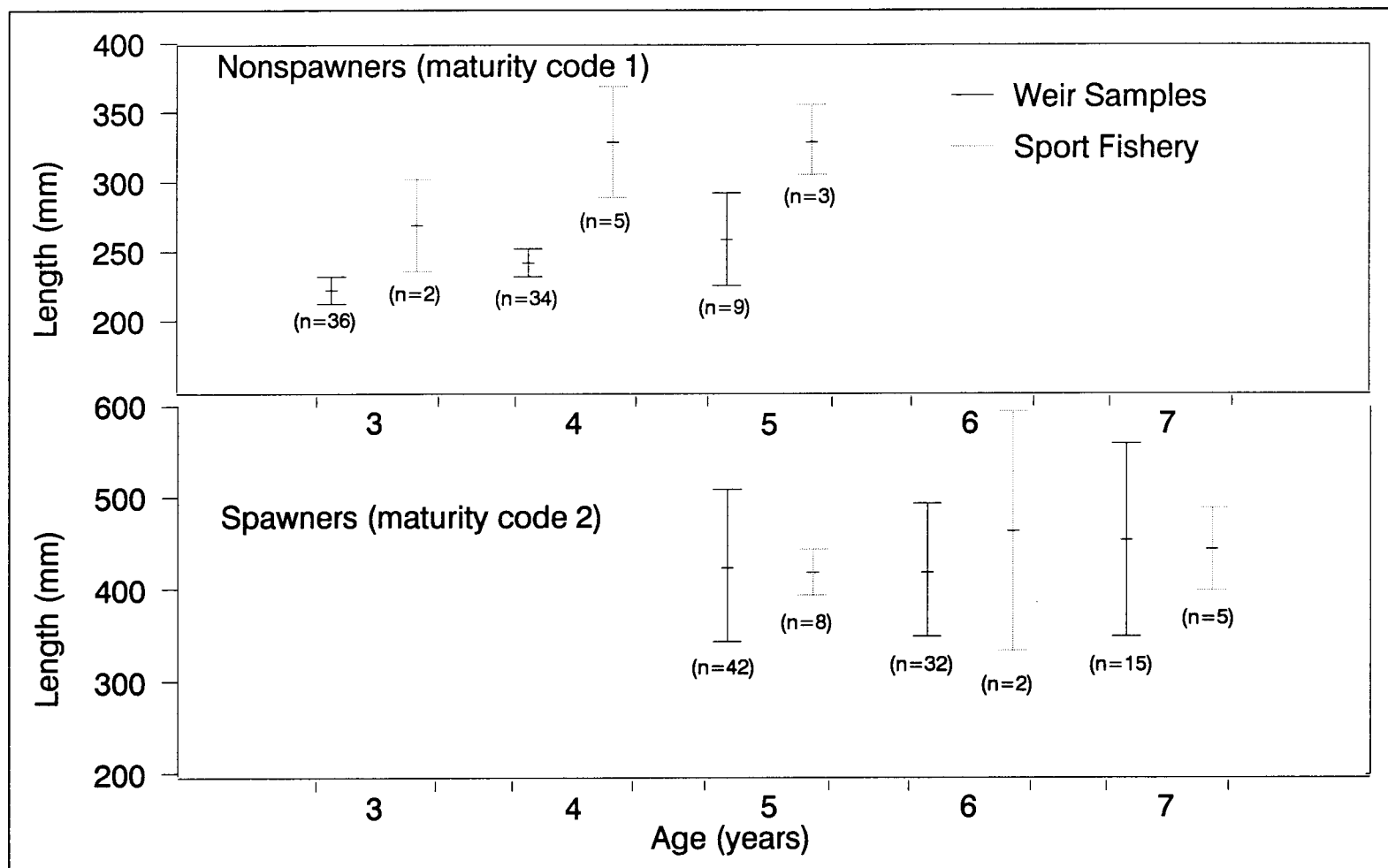


Figure 9. Mean length by age with 95% confidence intervals from nonspawner and spawner Anchor River Dolly Varden sampled at the weir and in the sport fishery, 1990.

Tag recoveries from Dolly Varden tagged on lower peninsula streams since 1986 total 1,013 with 27 tags recovered during 1990 (Table 11 and Appendix A9). During 1990, 4 tags were recovered in saltwater fisheries, 22 in the Anchor River, and 1 from the Kasilof River sport fishery. Of the Anchor River recoveries, three were recovered by anglers and 19 from the fish weir. The majority of the recovered tags (23) during 1990 were tagged in 1988, three tags were from 1987, and one tag was from 1989.

To date, 82% of the total recoveries were made 1 year after tagging and 18% 2 or more years later (Appendix A9). These results may change slightly as additional data are collected in upcoming years, however, few Dolly Varden were tagged after 1988 and these results are not expected to change radically. Only fish of spawning size (at least 300 mm in fork length) at the time of tagging were included in these estimates.

Annual growth in fork length was estimated from recaptured Dolly Varden that returned at least one summer after being tagged (Appendix 9). Fish originally tagged in the 250-299 mm length range showed the most growth, approximately 110 mm, while growth from the other length ranges varied from 45-80 mm (Figure 10).

DISCUSSION

The composition of the Anchor River Dolly Varden spawning stock has been evaluated during 1989 and 1990. I concluded from sampling for relative maturity at the weir during 1989 that fish greater than 300 mm fork length are mature fish. New evidence indicates that large nonspawners harvested in the sport fishery downstream of the weir may introduce a bias in the estimate of spawner and nonspawner sizes at the weir.

The sport fishery primarily harvests large fish, to include large spawners and nonspawners. The size of the nonspawners shown in Figure 9 indicates the 95% confidence interval of harvested fish lies completely outside the 95% confidence interval of weir samples for each age class, the harvested fish being larger than fish sampled at the weir.

An efficient sport fishery downstream of the weir could explain why large nonspawners are sampled in the sport fishery and not sampled at the weir. The primary purpose of nonspawners entering freshwater systems during summer is to feed and, for first time outmigrants, to look for an overwintering location (Armstrong 1967 and 1984). In their search for food, nonspawners are susceptible to being caught with bait and lures. In the Anchor River, larger fish are harvested by anglers (Tables 5 and 6) and the small fish are released after capture. The total nonspawner (maturity code 1) harvest was estimated at 490 fish (Table 6). Unfortunately, the sample size of sport harvested fish during 1990 was insufficient to estimate the level of significance between weir and sport harvest samples and the sample size of harvested fish must be increased during 1991 to complete this analysis.

Assuming nonspawners are fish of mixed origin (Armstrong 1967 and 1984), the harvest of large nonspawners from the Anchor River probably represents stocks

Table 11. Summary of lower Kenai Peninsula Dolly Varden tag and tag recovery, 1986-1990.

Tagging Data					Recovery Data																							Total				
					1987								1988								1989				1990							
Year	Site	Month	No. Days	No. Tagged	AR ^a		DC ^b		NR ^c		Salt ^d		CRC ^e		NR ^e		KR ^f		Salt ^f		AR		Salt		AR		KSR ^g		Salt ^g			
					Jul	Aug	Sep	Oct	Aug	Oct	Nov	May	Jul	Aug	Sep	Oct	Sep	Jul	Aug	Sep	Jul	May	Jun	Jul	Aug	Apr	Jun	Jul	Jul	Aug	Jul	Apr
1986	Anchor R.	Oct	2	79	2			1				1																			4	
1987	Anchor R.	Jul	24	1,690	53	35	8	5			1					6				3											111	
		Aug	30	1,412		189	21	10				18	1						1	2	1	2			1		3				249	
		Sep	8	105							2																				2	
	Deep Cr.	Jul	2	36		1		2	1			2																				6
		Aug	1	4																												
	Ninilchik	Sep	1	29																												
		Jul	2	13																												
		Sep	5	104				2			1						1					1										5
1988	Anchor R.	Jul	25	2,969									278	124	3	1		1				36	3	1	1		17	1		3	1	470
		Aug	3	54											3											1						4
	Ninilchik	Jul	17	734													1	117	18	2												138
		Aug	8	35																						1						
1989	Anchor R.	Jul	2	3																												
		Aug	19	262																		14							1			15
		Sep	2	4																												
		Oct	3	7																												
		Nov	3	8																												
		Total		7,548	55	225	29	20	1	1	1	1	300	128	3	1	1	125	18	2	1	5	1	39	17	1	2	1	21	1	1	3

^a AR = Anchor River

^b DC = Deep Creek

^c NR = Ninilchik River

^d SALT = Salt Water

^e CRC = Crooked Creek

^f KR = Kenai River

^g KSR = Kasilof River

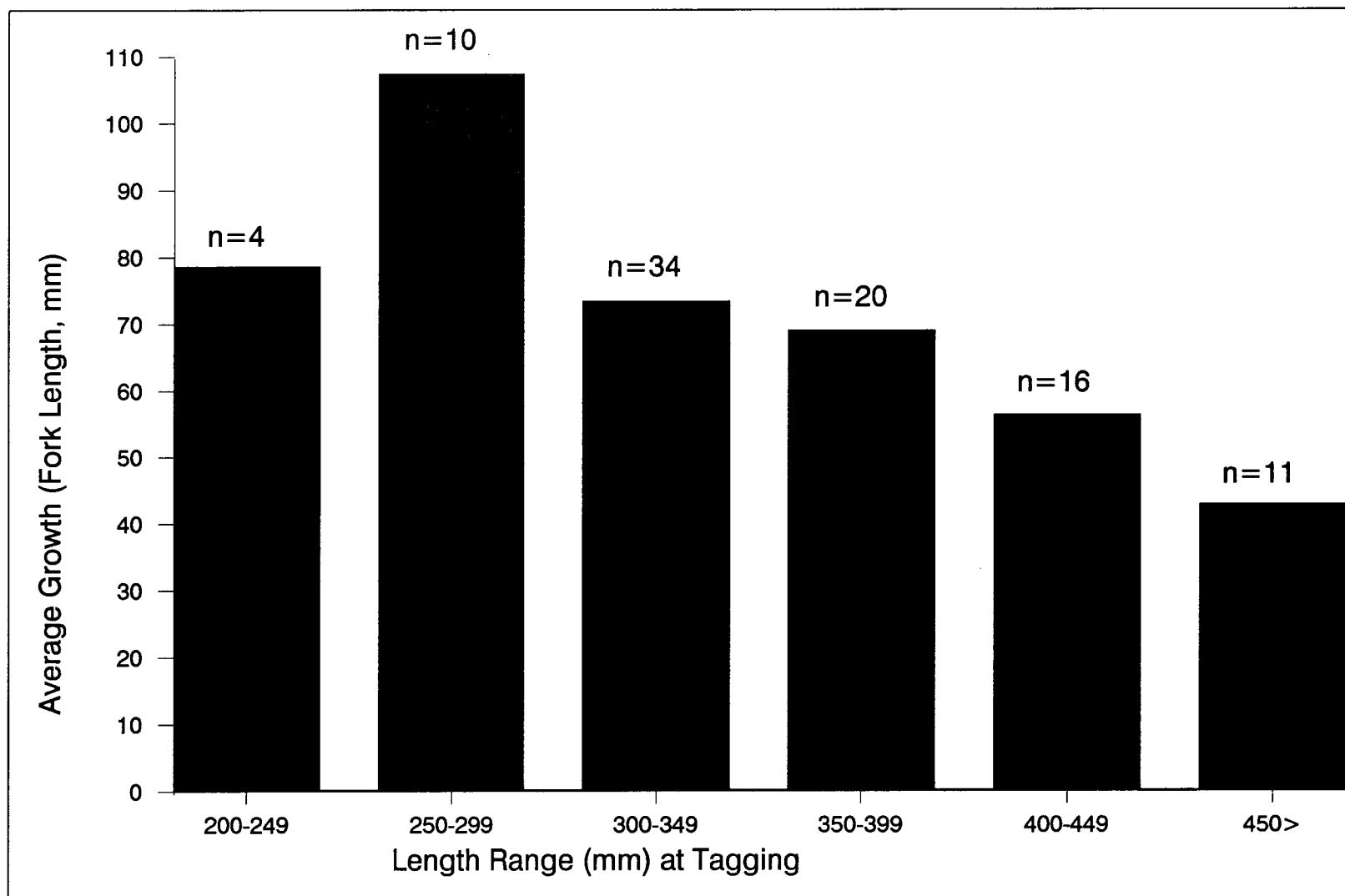


Figure 10. Average annual growth of Dolly Varden, based on length ranges at time of tagging on the Anchor River, 1987-1990.

from drainages throughout the Kenai Peninsula (Larson 1988). An estimated harvest of 490 large nonspawners from multiple drainages does not appear to be excessive but will impact the number of spawners available to these drainages in later years.

The average size of spawners, whether sampled from the sport fishery or at the weir, showed little variation (Table 5 and Figure 9). This stands to reason as nearly all spawners are considered large fish (over 300 mm fork length) and, if caught, probably have an equal likelihood of being retained.

The estimated spawner harvest of 1,009 fish represents 16% of the total estimated Anchor River spawner component during 1990 (Table 6). This is a minimal harvest level and does not account for angler induced or natural mortality. I feel that this level of spawner exploitation is excessive, especially with the declining run sizes observed since 1987.

A regulation change, to reduce the daily Dolly Varden bag limit from five to two, will be implemented during 1991. The new regulation will go into effect on the Anchor River, Deep Creek, Ninilchik River, and Stariski Creek. This decrease in the daily bag limit is expected to decrease the harvest by approximately one-third if the effort remains at 1990 levels. Although the Dolly Varden harvest is expected to be reduced, the number of fish released is expected to increase and the affect of angler hook and release practices remains unknown.

I am concerned with the mortality associated with hook and release. The percent of the total Dolly Varden population that was handled by the sport fishery (total catch/total abundance) averaged 50% from 1987 to 1990 and was highest (70%) in 1988. So, the sport fishery has the potential to handle from one-third to nearly three-fourths of the entire immigrating Dolly Varden population.

Angler induced mortality can occur directly from a hook wound or indirectly through stress induced diseases. During 1990, we examined mortalities recovered at the weir site. These were fish that had died upstream of the weir structure and washed downstream to the site. In this sample of 414 mortalities (Table 7), 64% (263) displayed evidence of hook wounds and nearly all hook wounds had bacterial infections associated with them. These mortalities observed at the weir do not quantify the level of angler induced mortality occurring in the Anchor River, however, I do feel they testify to the importance hook and release practices play in causing freshwater mortalities. Undoubtedly, all mortalities add to the already high level of exploitation occurring in the Dolly Varden recreational fishery.

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APPENDIX A
Biological Data

Appendix A1. Daily statistics for Anchor River Dolly Varden creel survey, 1990.

PERIOD ^a	DATE	Number of Interviews	Total Effort	Variance Effort	CPUE	Variance CPUE	Total Catch	Variance Catch	HPUE	Variance HPUE	Harvest	Variance Harvest
A	900703	2	8	48	0.000	0.000	0	0	0.000	0.000	0	0
A	900707	0	21	69								
A	900711	4	59	475	0.456	0.022	27	163	0.351	0.036	21	165
A	900715	5	139	1,333	0.000	0.000	0	0	0.000	0.000	0	0
A	900719	11	37	181	0.557	0.037	21	101	0.284	0.012	11	30
A	900723	15	75	181	0.295	0.011	22	78	0.213	0.008	16	50
A	900727	6	104	667	0.452	0.077	47	913	0.060	0.005	6	51
A	900731	14	61	1,589	1.767	0.245	108	5,496	1.083	0.116	66	2,117
A	900804	58	85	907	0.260	0.005	22	91	0.113	0.002	10	27
A	900808	24	61	133	0.000	0.000	0	0	0.000	0.000	0	0
A	900812	38	171	4,613	0.000	0.000	0	0	0.000	0.000	0	0
A	900813	0	136									
A	900816	11	179	853	0.068	0.005	12	172	0.000	0.000	0	0
A	900820	12	213	837	0.000	0.000	0	0	0.000	0.000	0	0
A	900824	17	341	267	0.000	0.000	0	0	0.000	0.000	0	0
A	900828	32	240	683	0.000	0.000	0	0	0.000	0.000	0	0
A	900901	4	365	4,187	0.000	0.000	0	0	0.000	0.000	0	0
B	900702	0	37	5								
B	900705	7	40	240	0.102	0.013	4	21	0.000	0.000	0	0
B	900708	0	80	1,200								
B	900711	4	213	3,675	0.236	0.065	50	2,924	0.115	0.005	25	272
B	900714	23	459	3,765	0.554	0.074	254	16,348	0.113	0.004	52	970
B	900717	9	283	987	0.402	0.094	114	7,555	0.402	0.094	114	7,555
B	900720	12	205	213	0.349	0.028	72	1,201	0.040	0.001	8	62
B	900723	16	144	240	0.593	0.040	85	907	0.271	0.018	39	394
B	900726	31	165	53	1.088	0.052	180	1,491	0.578	0.015	96	419
B	900729	30	181	1,387	0.568	0.039	103	1,664	0.228	0.010	41	390
B	900801	70	168	603	0.804	0.048	135	1,729	0.362	0.010	61	362
B	900804	8	128	1,200	0.570	0.158	73	2,786	0.143	0.023	18	370
B	900807	6	168	384	0.939	0.358	158	10,302	0.000	0.000	0	0
B	900810	31	144	3,120	0.000	0.000	0	0	0.000	0.000	0	0
B	900813	7	176	14,400	0.000	0.000	0	0	0.000	0.000	0	0
B	900816	13	179	2,629	0.000	0.000	0	0	0.000	0.000	0	0
B	900819	47	421	7,189	0.000	0.000	0	0	0.000	0.000	0	0
B	900822	21	411	1,333	0.000	0.000	0	0	0.000	0.000	0	0
B	900825	34	488	1,947	0.008	0.000	4	14	0.000	0.000	0	0
B	900828	5	525	4,485	0.000	0.000	0	0	0.000	0.000	0	0
B	900831	6	384	2,603	0.000	0.000	0	0	0.000	0.000	0	0

^a Period A = 0600 hours to 1359 hours and period B = 1400 hours to 2200 hours.

Appendix A2. Angler counts, by period, for the sport fishery on the
Anchor River from 3 July through 1 September 1990.

Date	Period A (0600-1359 hours)						Period B (1400-2159 hours)					
	<u>Count #1</u>		<u>Count # 2</u>		<u>Count # 3</u>		<u>Count # 1</u>		<u>Count # 2</u>		<u>Count # 3</u>	
	Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir
702							3	2	2	3	2	2
703	0	0	0	0	3	0						
705							3	2	8	0	1	1
707	0	0	3	0	2	3						
708							8	0	13	4	1	4
711	7	1	3	0	6	5	20	2	30	9	16	3
714							27	16	33	19	68	9
715	9	0	11	3	19	10						
717							35	5	27	2	31	6
719	4	3	2	0	5	0						
720							26	3	18	9	15	6
723	5	0	5	5	8	5	15	6	10	5	14	4
726							15	6	20	2	17	2
727	5	0	12	4	15	3						
729							22	12	9	9	12	4
731	0	0	0	3	14	6						
801							21	2	9	7	16	8
804	19	0	4	2	6	1	20	7	9	6	5	1
807							17	2	22	3	17	2
808	6	0	6	0	10	1						
810							16	3	7	0	28	0
812	41	2	13	2	6	0						
813							17	0	7	3	34	0
816	21	0	17	0	29	0	27	3	10	2	22	3
819							53	15	30	6	43	11
820	15	12	13	8	21	11						
822							44	19	33	15	27	16
824	38	9	33	7	27	14						
825							41	15	50	20	45	12
828	20	2	22	8	22	16	63	22	40	16	44	12
831							43	11	44	12	25	9
901	21	4	30	18	39	25						

Appendix A3. Summary of completed angler responses to questions on the use of terminal tackle, residency, and fishing location, by date, 3 July-7 August 1990.

Date	Terminal Tackle			Residency				Fishing Location	
	Bait	Lures	Both Bait and Lures	Resident	Non Resident	Local ^a	Non Local ^b	Downstream of Weir	Upstream of Weir
03-Jul	0	2	0	0	2	0	0	2	0
05-Jul	4	1	0	0	5	0	0	5	0
11-Jul	3	5	0	3	5	0	3	8	0
14-Jul	4	19	0	14	9	6	8	22	1
15-Jul	0	5	0	5	0	0	5	5	0
17-Jul	0	9	0	6	3	5	1	9	0
19-Jul	0	10	1	7	4	4	3	8	3
20-Jul	2	5	0	4	8	0	4	11	1
23-Jul	0	31	0	20	11	8	12	26	5
26-Jul	4	27	0	23	8	12	11	31	0
27-Jul	0	5	0	0	5	0	0	5	0
29-Jul	6	23	1	17	13	8	9	29	1
31-Jul	2	12	0	12	2	10	2	14	0
01-Aug	4	60	2	26	44	8	18	64	6
04-Aug	4	38	2	31	14	21	10	45	0
07-Aug	<u>0</u>	<u>4</u>	<u>0</u>	<u>4</u>	<u>0</u>	<u>3</u>	<u>1</u>	<u>4</u>	<u>0</u>
Total:	33	256	6	172	133	85	87	288	17

^a Resident angler living less than 35 km from Anchor Point.

^b Resident angler living greater than 35 km from Anchor Point.

Appendix A4. Daily river water depth and temperature readings recorded at the Anchor River weir upstream trap, 1990.^a

Date	Water Depth (cm)	Thermograph Reading		
		HIGHS (Celsius)	LOWS (Celsius)	Difference (Celsius)
04-Jul	32.5			
05-Jul	32.5			
06-Jul	33.8			
07-Jul	33.8			
08-Jul	33.8			
09-Jul	33.8	14.0	11.0	3.0
10-Jul	34.4	14.8	10.8	4.0
11-Jul	37.5	14.0	11.6	2.4
12-Jul	35.0	13.5	10.6	2.9
13-Jul	35.0	12.8	10.2	2.6
14-Jul	32.5	13.3	10.7	2.6
15-Jul	32.5	17.6	11.0	6.6
16-Jul	32.5	18.3	11.7	6.6
17-Jul	31.3	18.9	12.3	6.6
18-Jul	31.3	19.7	12.8	6.9
19-Jul	31.3	19.7	13.7	6.0
20-Jul	30.0	17.5	14.7	2.8
21-Jul	31.3	15.1	12.3	2.8
22-Jul	31.3	18.3	12.5	5.8
23-Jul	31.3	17.2	13.2	4.0
24-Jul	31.9	15.5	13.1	2.4
25-Jul	35.6	15.9	11.6	4.3
26-Jul	35.0	14.7	12.2	2.5
27-Jul	33.8	12.7	11.2	1.5
28-Jul	33.8	13.5	11.2	2.3
29-Jul	35.0	12.7	11.0	1.7
30-Jul	33.8	13.1	11.0	2.1
31-Jul	32.5	12.7	11.0	1.7

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Appendix A4. (Page 2 of 2).

Date	Water Depth (cm)	<u>Thermograph Reading</u>		
		HIGHS (Celsius)	LOWS (Celsius)	Difference (Celsius)
01-Aug	36.3	12.0	10.7	1.3
02-Aug	38.8	11.8	10.5	1.3
03-Aug	36.3	13.5	10.6	2.9
04-Aug	41.3	13.3	11.9	1.4
05-Aug	38.8	15.7	10.1	5.6
06-Aug	36.3	14.5	12.4	2.1
07-Aug	34.4	14.6	10.8	3.8
08-Aug	33.8	13.3	10.8	2.5
09-Aug	35.0	12.0	11.0	1.0
10-Aug	40.0	12.0	11.1	0.9
11-Aug	37.5	15.3	10.8	4.5
12-Aug	36.3	17.8	12.3	5.5
13-Aug	35.0	18.2	12.4	5.8
14-Aug	33.8	18.5	13.3	5.2
15-Aug	32.5	18.0	14.0	4.0

^a Water temperature was recorded continually by thermograph while river depth was instantaneously recorded at 2200 hours daily. River water depth was relative to a selected location on the upstream trap.

Appendix A5. Number of fish, by species and date, passed upstream through the Anchor River weir during 1990. Also included is the number of recaptured Dolly Varden that had been tagged in previous years.

Date	Number Dolly V. Tags Recov.	Species ^a						
		DV	SS	PS	KS	RS	CS	SH
04-Jul								
05-Jul		6		1	4			
06-Jul		15			3			
07-Jul		8		1	12			
08-Jul		22		6	3			
09-Jul		41		3	8	1		
10-Jul		42		4	3			
11-Jul	2	176		6	5			
12-Jul	1	201		8	10			
13-Jul	2	121		7	2			
14-Jul		167		4	2	1		
15-Jul	3	402		5	4			
16-Jul	4	590		5	2			
17-Jul	1	1,068		7	2			
18-Jul	1	967		9				
19-Jul		699		2				
20-Jul	1	611		6	1			
21-Jul	2	549		4	2			
22-Jul	1	617	1	4	1			
23-Jul		608		5	2			
24-Jul		327		3		1		
25-Jul		211		2				
26-Jul		487		19	9		1	
27-Jul		228		4	4	1		
28-Jul		118	2	1	4			
29-Jul		147	1	8	4	2	2	
30-Jul		95	1	6	4	1		
31-Jul		96		10	2	2		
01-Aug		93	1	14	13	1	1	
02-Aug		123		10	16	3	2	
03-Aug		105	1	17	2	3	2	
04-Aug		146	9	25	6			
05-Aug		209	9	9	1	1		

-continued-

Appendix A5. (Page 2 of 2).

Date	Number Dolly V. Tags Recov.	Species ^a						
		DV	SS	PS	KS	RS	CS	SH
06-Aug		142	2	8		4		
07-Aug		86	4	10		2		
08-Aug		57	1	5	3	1	2	
09-Aug		56	1	6		3	2	
10-Aug		67	91	49	4	8	2	2
11-Aug		62	10	16	2		1	
12-Aug		289	20	12	1	2	1	
13-Aug		194	14	20	1	1		1
14-Aug		112	12	3	2	1	1	
15-Aug		67	10	11				
Totals: 18		10,427	190	355	144	39	17	3

^a Species: DV = Dolly Varden SS = coho salmon
 PS = pink salmon KS = chinook salmon
 RS = sockeye salmon CS = chum salmon
 SH = steelhead/rainbow trout

Appendix A6. The daily and cumulative number of fish, by species, passed downstream through the Anchor River weir during 1990.

DATE	<u>Dolly Varden</u>		<u>Chinook S.</u>		<u>Pink Salmon</u>		<u>Sockeye S.</u>		<u>Coho Salmon</u>	
	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count	Daily Count	Cum Count
04-Jul	1	1	1	1	1	1		0		0
05-Jul	2	3	2	3	2	3		0		0
06-Jul	1	4		3		3		0		0
07-Jul	2	6	2	5		3		0		0
08-Jul	2	8	2	7		3		0		0
09-Jul		8	1	8		3		0		0
10-Jul	1	9	2	10	1	4		0		0
11-Jul	1	10		10		4		0		0
12-Jul		10		10		4		0		0
13-Jul	1	11		10	2	6		0		0
14-Jul	1	12		10	1	7		0		0
15-Jul		12	2	12		7		0		0
16-Jul	2	14		12	1	8		0		0
17-Jul	3	17	1	13		8		0		0
18-Jul	2	19		13	1	9		0		0
19-Jul	12	31	1	14		9		0		0
20-Jul	2	33	2	16		9		0		0
21-Jul	12	45	1	17		9		0		0
22-Jul	14	59		17		9		0		0
23-Jul	30	89	2	19		9		0		0
24-Jul	28	117		19		9		0		0
25-Jul	31	148	2	21	4	13		0		0
26-Jul	26	174	3	24		13		0		0
27-Jul	28	202	1	25	2	15		0		0
28-Jul	15	217		25		15		0		0
29-Jul	10	227	2	27	1	16		0		0
30-Jul	5	232	2	29	1	17		0		0
31-Jul	33	265	4	33	6	23		0		0
01-Aug	17	282	7	40	6	29		0		0
02-Aug	21	303	4	44	4	33	1	1		0
03-Aug	26	329	6	50	5	38		1		0
04-Aug	11	340	4	54	7	45		1		0
05-Aug	15	355	6	60	10	55		1		0
06-Aug	23	378	9	69	11	66		1		0
07-Aug	12	390	4	73	16	82	1	2		0
08-Aug	11	401	12	85	9	91		2		0
09-Aug	8	409	6	91	14	105		2	1	1
10-Aug	8	417	9	100	23	128		2		1
11-Aug		417	12	112	17	145		2		1
12-Aug		417	1	113	22	167		2		1
13-Aug	6	423	2	115	18	185		2		1
14-Aug	8	431	1	116	17	202		2		1
15-Aug		431	1	117	13	215		2	1	2

Appendix A7. Daily summary of Dolly Varden age compositions from fish sampled at random from the upstream trap of the Anchor River weir, 1990.

Date	Age Group									Daily Total
	2	3	4	5	6	7	8	9	12	
07-Jul	0	0	0	0	3	0	0	0	0	3
10-Jul	0	4	4	5	4	1	0	0	0	18
11-Jul	1	1	2	12	10	4	0	1	0	34
12-Jul	0	4	3	2	1	0	0	0	1	11
13-Jul	0	0	0	4	2	2	0	0	0	8
14-Jul	0	6	7	12	10	6	1	0	0	42
24-Jul	0	5	4	4	0	1	0	0	0	14
25-Jul	0	16	23	41	16	7	0	0	0	103
07-Aug	0	16	24	8	1	2	0	0	0	51
08-Aug	0	13	28	10	3	2	0	0	0	56
09-Aug	1	12	11	1	1	0	0	0	0	26
Totals:	2	77	106	102	51	25	1	1	1	369

Appendix A8. Dolly Varden samples collected at random from the upstream trap of the Anchor River fish weir showing daily summaries of female gonad maturity and sex ratios, 1990.

Date	Female Maturity Index ^a					Sex Totals		Sample Size
	1	2	3	4	5	Females	Males	
07-Jul	1	1				2	1	3
10-Jul	3	5			1	9	9	18
11-Jul	2	18			6	26	8	34
12-Jul	2	6				8	4	12
13-Jul		5			1	6	2	8
14-Jul	4	14			7	25	16	41
24-Jul	2	4			1	7	7	14
25-Jul	14	35			11	60	45	105
07-Aug	21	7			5	33	18	51
08-Aug	25	2	1		13	41	16	57
09-Aug	9	2			2	13	13	26
TOTAL	83	99	1	0	47	230	139	369

^a Maturity Index Codes:

- 1 = immature female with egg diameter less than 0.90 mm,
- 2 = mature female with egg diameter greater than 1.75 mm,
- 3 = completely mature female (eggs easily stripped),
- 4 = completely spawned female,
- 5 = immature female but shows development, egg diameter greater than 0.90 mm and less than 1.75 mm.

Appendix A9. Dolly Varden tag and recovery summary of fish tagged, by tag number, in the Anchor River, Deep Creek, and Ninilchik River and recovered at least one season later, 1986-1990.

Tag Number	Date Tagged	Tag Length (mm)	Date Recovered	Recov. Length (mm)	Elapsed Days	Total Growth (mm)	Est. Yearly Growth (mm)	Location Tagged ^a	Location Recovered ^a	Subloc. Recovered ^a	Source of Recovery ^b
320	11-Aug-87	215	11-Jul-90	490	1065	275	94	ARW	ARW	UST	ADF&G
181	09-Aug-87	224	21-Jul-88	295	347	71	75	ARW	AR	UST	ADF&G
3441	08-Aug-87	239	16-Jul-88	303	343	64	68	ARW	NRW	UST	ADF&G
357	11-Aug-87	242	17-Jul-90	470	1071	228	78	ARW	ARW	UST	ADF&G
2843	02-Aug-87	250	16-Jul-88	404	349	154	161	ARW	AR	UST	ADF&G
360	11-Aug-87	251	11-Jul-90	480	1065	229	78	ARW	ARW	UST	ADF&G
4235	07-Sep-87	256	16-Jul-88	333	313	77	90	ARW	AR	UST	ADF&G
191	09-Aug-87	257	16-Jul-88	348	342	91	97	ARW	AR	UST	ADF&G
118790	17-Aug-89	259	06-Jul-90	-	323	-	-	ARW	KSR		Angler
460	14-Aug-87	271	20-Jul-88	370	341	99	106	ARW	AR	UST	ADF&G
117421	20-Jul-88	271	17-Jul-90	459	727	188	94	ARW	AR	SLIDE	Angler
993	22-Sep-87	278	27-Jul-89	444	674	166	90	NR	ARW	UST	ADF&G
118457	25-Jul-88	295	20-Jul-89	485	360	190	193	ARW	ARW	UST	ADF&G
117806	23-Jul-88	298	15-Jul-90	411	722	113	57	ARW	ARW	UST	ADF&G
1066	13-Jul-87	300	09-Jul-88	393	362	93	94	ARW	AR	UST	ADF&G
118221	28-Jul-88	301	30-Apr-89	306	276	5	7	ARW	SALT	H. SPIT	Angler
4087	25-Aug-87	302	26-Jul-88	392	336	90	98	ARW	AR	UST	ADF&G
116349	15-Jul-88	306	22-Apr-90	450	646	144	81	ARW	SALT	H. SPIT	Angler
116472	15-Jul-88	307	21-Jul-90	412	736	105	52	ARW	ARW	UST	Angler
813	09-Jul-88	314	21-Jul-89	404	377	90	87	ARW	ARW	UST	ADF&G
737	08-Jul-88	315	15-Jul-89	337	372	22	22	ARW	ARW	UST	ADF&G
852	09-Jul-88	315	23-Jul-89	405	379	90	87	ARW	ARW	UST	ADF&G
117715	22-Jul-88	316	30-Jul-89	430	373	114	112	ARW	ARW	UST	ADF&G
3467	08-Aug-87	317	09-Jul-88	403	336	86	93	ARW	AR	UST	ADF&G
117344	19-Jul-88	317	28-Jul-89	380	374	63	61	ARW	ARW	UST	ADF&G
116463	15-Jul-88	318	28-Jul-89	475	378	157	152	ARW	ARW	UST	ADF&G
829	09-Jul-88	319	12-Jul-89	410	368	91	90	ARW	ARW	UST	ADF&G
116049	12-Jul-88	320	18-Jul-89	330	371	10	10	ARW	ARW	UST	ADF&G
2071	25-Jul-87	321	18-Jul-88	398	359	77	78	ARW	AR	UST	ADF&G
117792	23-Jul-88	324	23-Jul-89	410	365	86	86	ARW	ARW	UST	ADF&G
3290	06-Aug-87	325	28-Jul-88	465	357	140	143	ARW	AR	UST	ADF&G
118192	27-Jul-88	325	28-Jul-89	421	366	96	96	ARW	ARW	UST	ADF&G
97	10-Jul-88	326	28-Jul-89	382	383	56	53	ARW	ARW	UST	ADF&G
117312	19-Jul-88	326	31-Jul-89	402	377	76	74	ARW	ARW	UST	ADF&G
1622	19-Jul-87	327	13-Jul-88	401	360	74	75	ARW	AR	UST	ADF&G
226	09-Aug-87	327	26-Jul-88	418	352	91	94	ARW	AR	UST	ADF&G
709	08-Jul-88	330	27-Apr-90	400	658	70	39	ARW	SALT	H. SPIT	Angler
116708	16-Jul-88	330	15-Jul-90	450	729	120	60	ARW	ARW	UST	ADF&G
118653	13-Aug-88	337	19-Jul-90	395	705	58	30	ARW	ARW	UST	ADF&G
117704	22-Jul-88	338	28-Jul-89	390	371	52	51	ARW	ARW	UST	ADF&G

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Appendix A9. (Page 2 of 3).

Tag Number	Date Tagged	Tag Length (mm)	Date Recovered	Recov. Length (mm)	Elapsed Days	Total Growth (mm)	Est. Yearly Growth (mm)	Location Tagged ^a	Location Recovered ^a	Subloc. Recovered ^a	Source of Recovery ^b
118162	27-Jul-88	338	20-Jul-90	460	723	122	62	ARW	ARW	UST	ADF&G
116053	12-Jul-88	340	13-Jul-90	474	731	134	67	ARW	ARW	UST	ADF&G
116125	12-Jul-88	340	26-Jul-89	435	379	95	91	ARW	ARW	UST	ADF&G
117533	20-Jul-88	343	18-Jul-89	415	363	72	72	ARW	ARW	UST	ADF&G
4114	27-Aug-87	345	09-Jul-88	387	317	42	48	ARW	AR	UST	ADF&G
799	10-Jul-88	345	24-Jul-89	440	379	95	91	ARW	ARW	UST	ADF&G
118380	29-Jul-88	345	31-Jul-89	414	367	69	69	ARW	ARW	UST	ADF&G
569	17-Aug-87	350	21-Jul-88	427	339	77	83	ARW	AR	UST	ADF&G
642	08-Jul-88	350	16-Jul-90	465	738	115	57	ARW	ARW	UST	ADF&G
763	09-Jul-88	350	01-May-90	400	661	50	28	ARW	SALT	H. SPIT	Angler
379	12-Aug-87	353	18-Jul-88	422	341	69	74	ARW	AR	UST	ADF&G
117155	18-Jul-88	355	26-Jul-89	438	373	83	81	ARW	ARW	UST	ADF&G
6990	20-Jul-87	358	15-Jul-88	550	361	192	194	DC	AR	UST	ADF&G
118328	29-Jul-88	360	04-Jul-90	460	705	100	52	ARW	SALT	PETERSON B. COMM.	
1084	13-Jul-87	367	19-Jul-88	473	372	106	104	ARW	AR	UST	ADF&G
116566	16-Jul-88	367	12-Jul-90	492	726	125	63	ARW	ARW	UST	ADF&G
118161	27-Jul-88	370	24-Jul-89	435	362	65	66	ARW	ARW	UST	ADF&G
117809	23-Jul-88	387	30-Jul-89	443	372	56	55	ARW	ARW	UST	ADF&G
280	10-Aug-87	390	22-Jul-88	448	347	58	61	ARW	AR	UST	ADF&G
631	08-Jul-88	390	15-Jul-90	545	737	155	77	ARW	ARW	UST	ADF&G
2	10-Jul-88	390	28-Jul-89	445	383	55	52	ARW	ARW	UST	ADF&G
116884	17-Jul-88	390	29-Jul-89	433	377	43	42	ARW	ARW	UST	ADF&G
117234	19-Jul-88	390	16-Jul-90	495	727	105	53	ARW	ARW	UST	ADF&G
117436	20-Jul-88	390	28-Jul-89	433	373	43	42	ARW	ARW	UST	ADF&G
118491	29-Jul-88	398	24-Jul-89	490	360	92	93	ARW	ARW	UST	ADF&G
4244	08-Sep-87	399	18-Jul-88	452	314	53	62	ARW	AR	UST	ADF&G
118354	29-Jul-88	399	16-Jul-90	484	717	85	43	ARW	ARW	UST	ADF&G
116261	14-Jul-88	400	27-Jul-89	575	378	175	169	ARW	ARW	UST	ADF&G
116437	15-Jul-88	400	27-Jul-89	457	377	57	55	ARW	ARW	UST	ADF&G
116610	16-Jul-88	402	20-Jul-89	425	369	23	23	ARW	ARW	UST	ADF&G
3141	05-Aug-87	404	18-Jul-88	458	348	54	57	ARW	AR	UST	ADF&G
943	24-Sep-87	410	17-Jul-88	450	297	40	49	NR	NRW	UST	ADF&G
1457	17-Jul-87	411	15-Jul-88	466	364	55	55	ARW	AR	UST	ADF&G
777	09-Jul-88	412	29-Jul-89	485	385	73	69	ARW	ARW	UST	ADF&G
116026	12-Jul-88	415	16-Jul-90	515	734	100	50	ARW	ARW	UST	ADF&G
117193	19-Jul-88	418	01-Aug-89	465	378	47	45	ARW	ARW	UST	ADF&G
459	11-Jul-88	421	29-Jul-89	443	383	22	21	ARW	ARW	UST	ADF&G
116290	15-Jul-88	424	28-Jul-89	475	378	51	49	ARW	ARW	UST	ADF&G
117622	21-Jul-88	430	27-Jul-89	480	371	50	49	ARW	ARW	UST	ADF&G
117310	19-Jul-88	435	20-Jul-89	505	366	70	70	ARW	ARW	UST	ADF&G
118253	28-Jul-88	435	13-Jul-90	496	715	61	31	ARW	ARW	UST	ADF&G
116125	26-Jul-89	435	21-Jul-90	486	360	51	52	ARW	ARW	UST	ADF&G

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Appendix A9. (Page 3 of 3).

Tag Number	Date Tagged	Tag Length (mm)	Date Recovered	Recov. Length (mm)	Elapsed Days	Total Growth (mm)	Est. Yearly Growth (mm)	Location Tagged ^a	Location Recovered ^a	Subloc. Recovered ^a	Source of Recovery ^b
116470	15-Jul-88	450	25-Jul-89	510	375	60	58	ARW	ARW	UST	ADF&G
118319	29-Jul-88	451	22-Jul-90	534	723	83	42	ARW	ARW	UST	ADF&G
116019	12-Jul-88	455	26-Jul-89	532	379	77	74	ARW	ARW	UST	ADF&G
118622	04-Aug-88	469	01-Aug-89	520	362	51	51	ARW	ARW	UST	ADF&G
116032	12-Jul-88	475	21-Jul-89	530	374	55	54	ARW	ARW	UST	ADF&G
116634	16-Jul-88	476	03-Aug-89	520	383	44	42	ARW	ARW	UST	ADF&G
117622	27-Jul-89	480	21-Jul-90	512	359	32	33	ARW	ARW	UST	ADF&G
1930	23-Jul-87	515	15-Jul-88	550	358	35	36	ARW	AR	UST	ADF&G
878	09-Jul-88	525	11-Jul-89	570	367	45	45	ARW	ARW	UST	ADF&G
116019	26-Jul-89	532	18-Jul-90	542	357	10	10	ARW	ARW	UST	ADF&G

^a Locations:

AR = Anchor River
 ARW = Anchor River Weir (RM 1.0)
 DC = Deep Creek
 H. SPIT = Homer Spit
 KSR = Kasilof River
 NR = Ninilchik River
 NRW = Ninilchik River Weir
 PETERSON B. = Peterson Bay
 SALT = Salt water
 SLIDE = Anchor River (RM 0.75)
 UST = Upstream Trap (RM 1.0)

^b Source: ADF&G = Alaska Department of Fish and Game
 COMM. = Commercial fishery

